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Anderson et al.

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(54) **STEAM HUMIDIFIER QUICK LIQUID CONNECTION**

(75) Inventors: **Wayne R. Anderson**, Eden Prairie, MN (US); **Steven L. Wolff**, Corcoran, MN (US); **Brad Alan Terlson**, Maple Grove, MN (US)

(73) Assignee: **Honeywell International Inc.**, Morristown, NJ (US)

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(51) **Int. Cl.**
B01F 3/04 (2006.01)

(52) **U.S. Cl.** **261/49**; 261/58; 261/71; 261/72.1; 261/DIG. 76; 29/700

(58) **Field of Classification Search** .... 261/42, 261/43, 49, 58, 66, 71, 72.1, 115, 118, 119.1, 261/141, 142, DIG. 10, DIG. 15, DIG. 65, 261/DIG. 76; 29/700; 239/136
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,031,918 A 6/1977 Cagle
4,211,735 A * 7/1980 Berlin 261/116
6,398,196 B1 * 6/2002 Light et al. 261/130
7,068,924 B2 * 6/2006 Watanabe et al. 392/386

OTHER PUBLICATIONS

Pictures of Hayward Universal Stop Cock Valves, Oct. 29, 2007, 3 pages.
"Control Valves," Hayward Flow Control Systems, from www.haywardindustrial.com/pdf/__control-valves/Needle__Angle__Univ.pdf, pp. 41-42, 2007.
"heaterSteam Electric Element Steam Humidifiers Installation and Maintenance Manual," Carel, 2007.

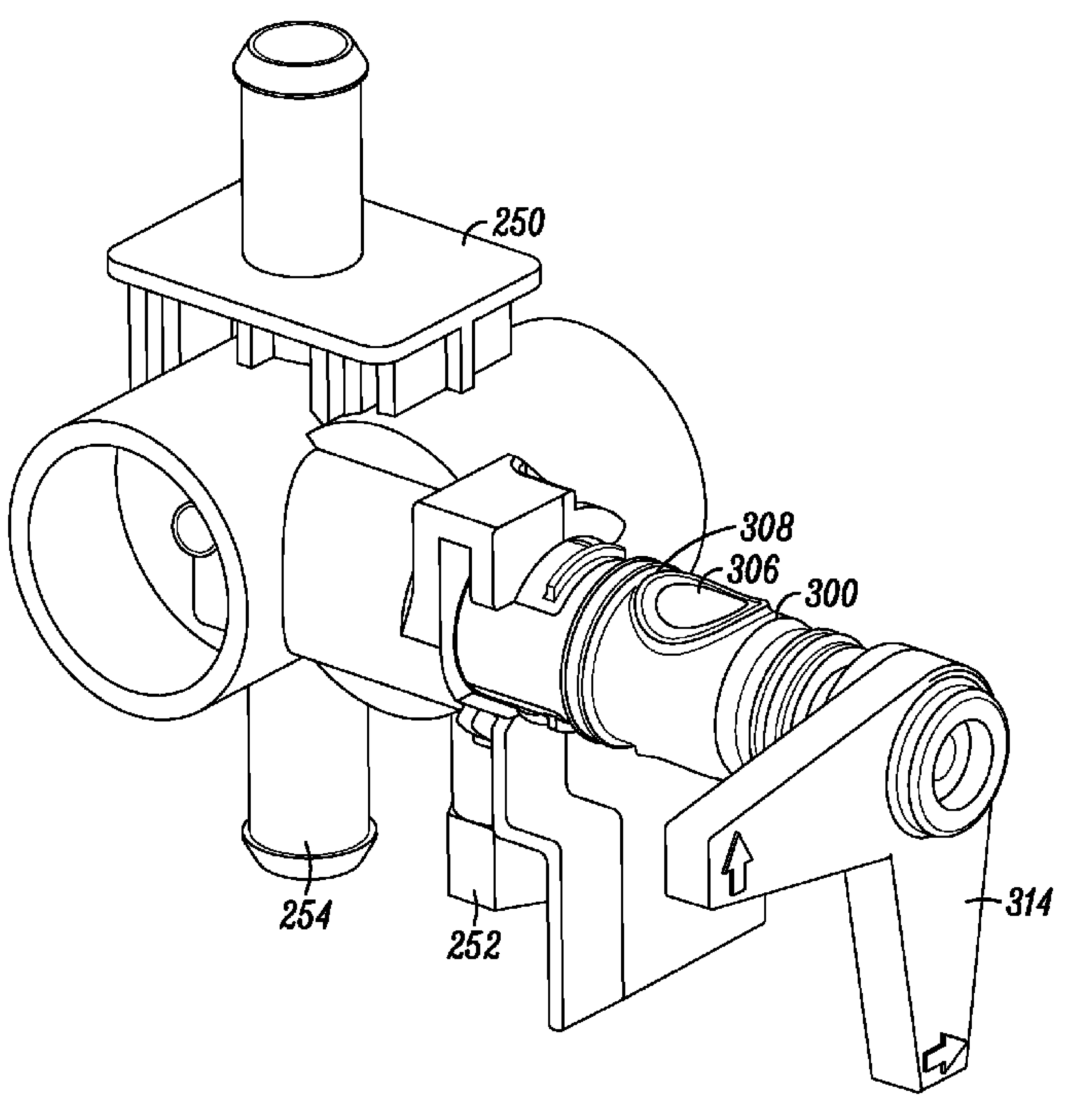
* cited by examiner

Primary Examiner—Scott Bushey

(57) **ABSTRACT**

In one aspect, a steam humidifier is disclosed. The steam humidifier includes a tank for containing water to be heated to generate steam and a water connection manifold that has a manifold chamber in fluid communication with a water supply passage and a water drain passage. The steam humidifier further includes a rotary valve that is configured to control a fluid passage between the tank and the manifold chamber and that is further configured to control the position of one or more locking features. The rotary valve is rotatable between a first locked position and a second unlocked position. In the first locked position, the fluid passage between the tank and the manifold chamber is open and the one or more locking features are engaged with a structure of the steam humidifier. In the second unlocked position, the fluid passage between the tank and the manifold chamber is closed and the one or more locking features are disengaged from the structure of the steam humidifier. Other aspects are disclosed.

19 Claims, 17 Drawing Sheets



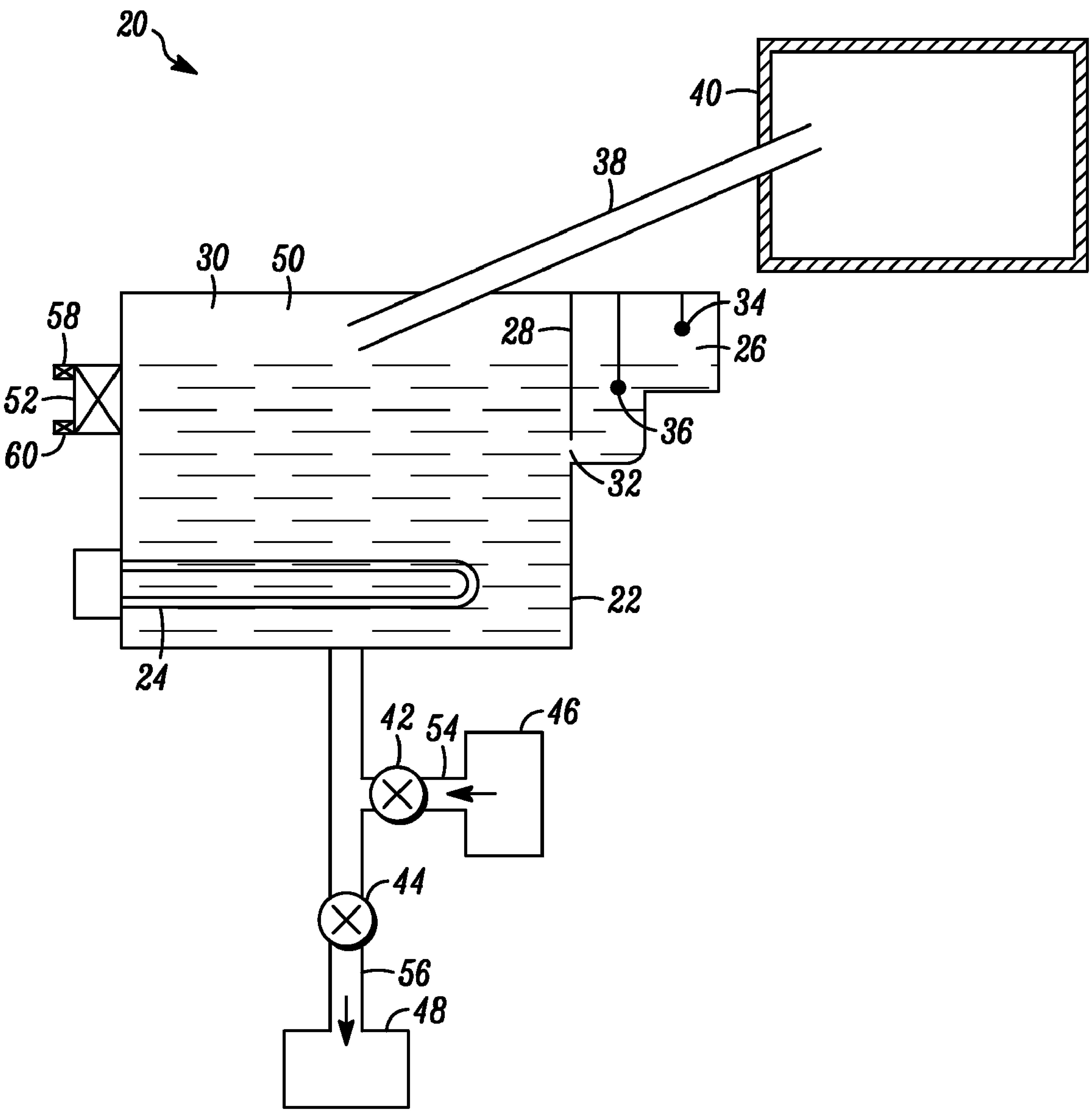


FIG. 1

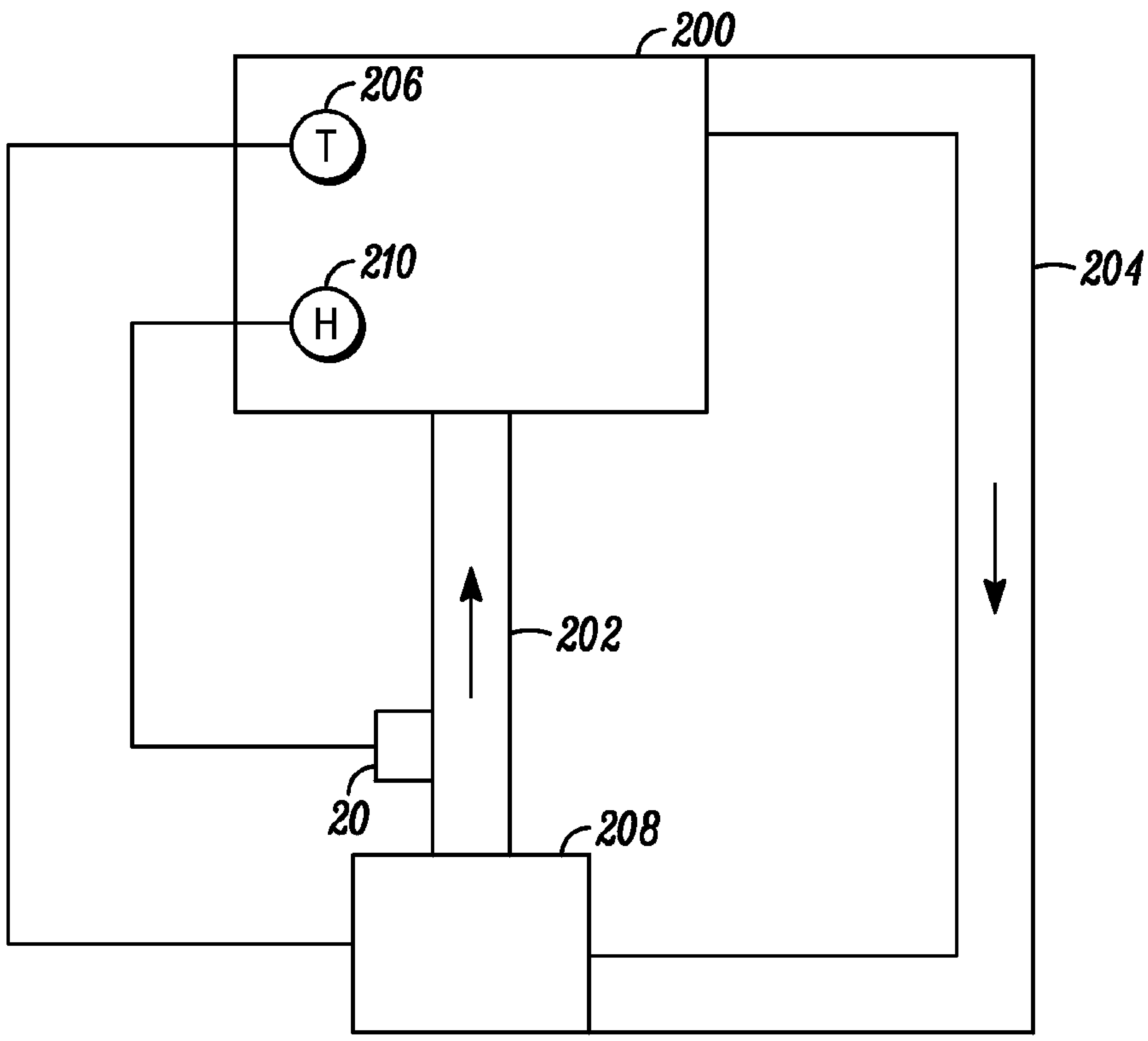


FIG. 2

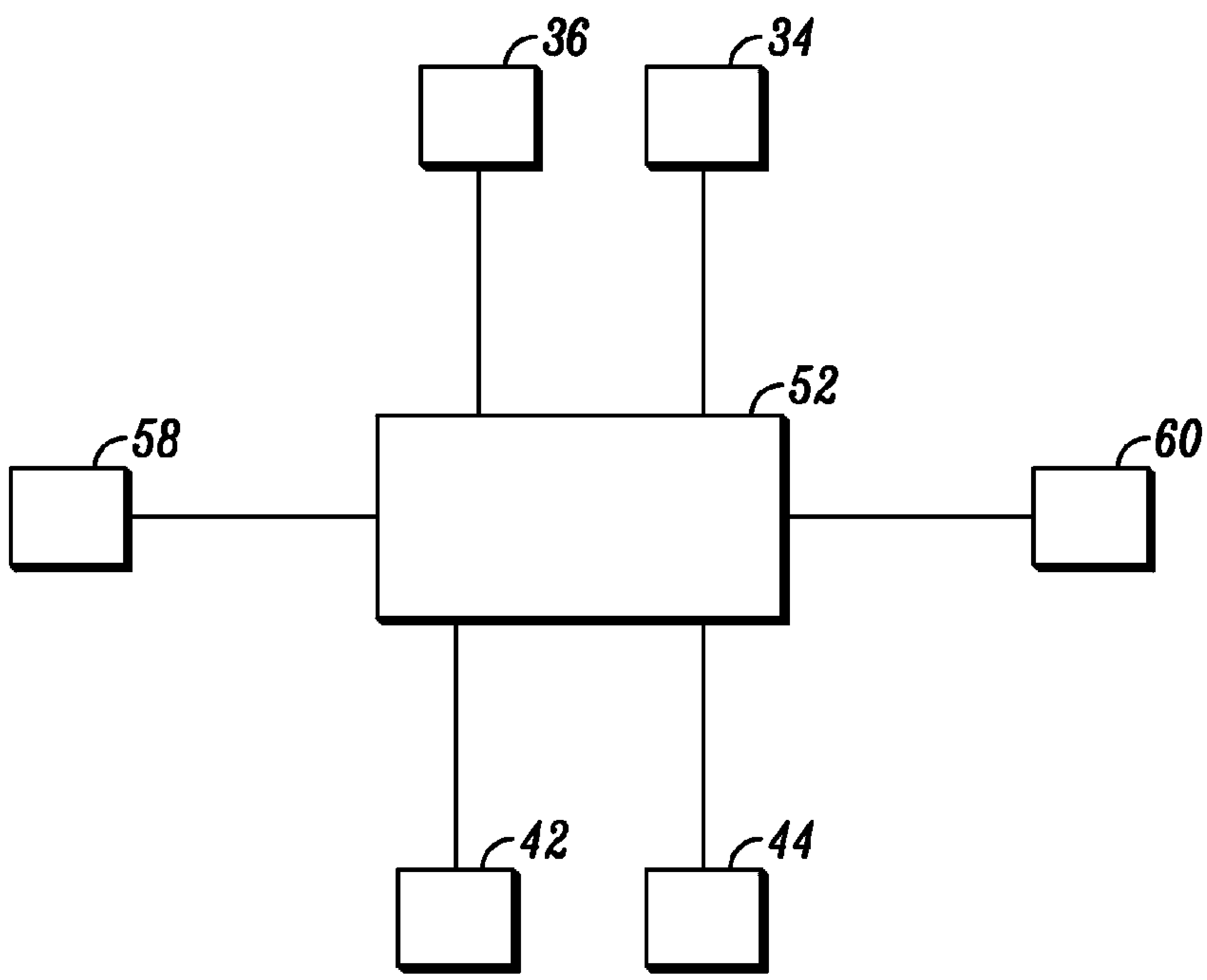


FIG. 3

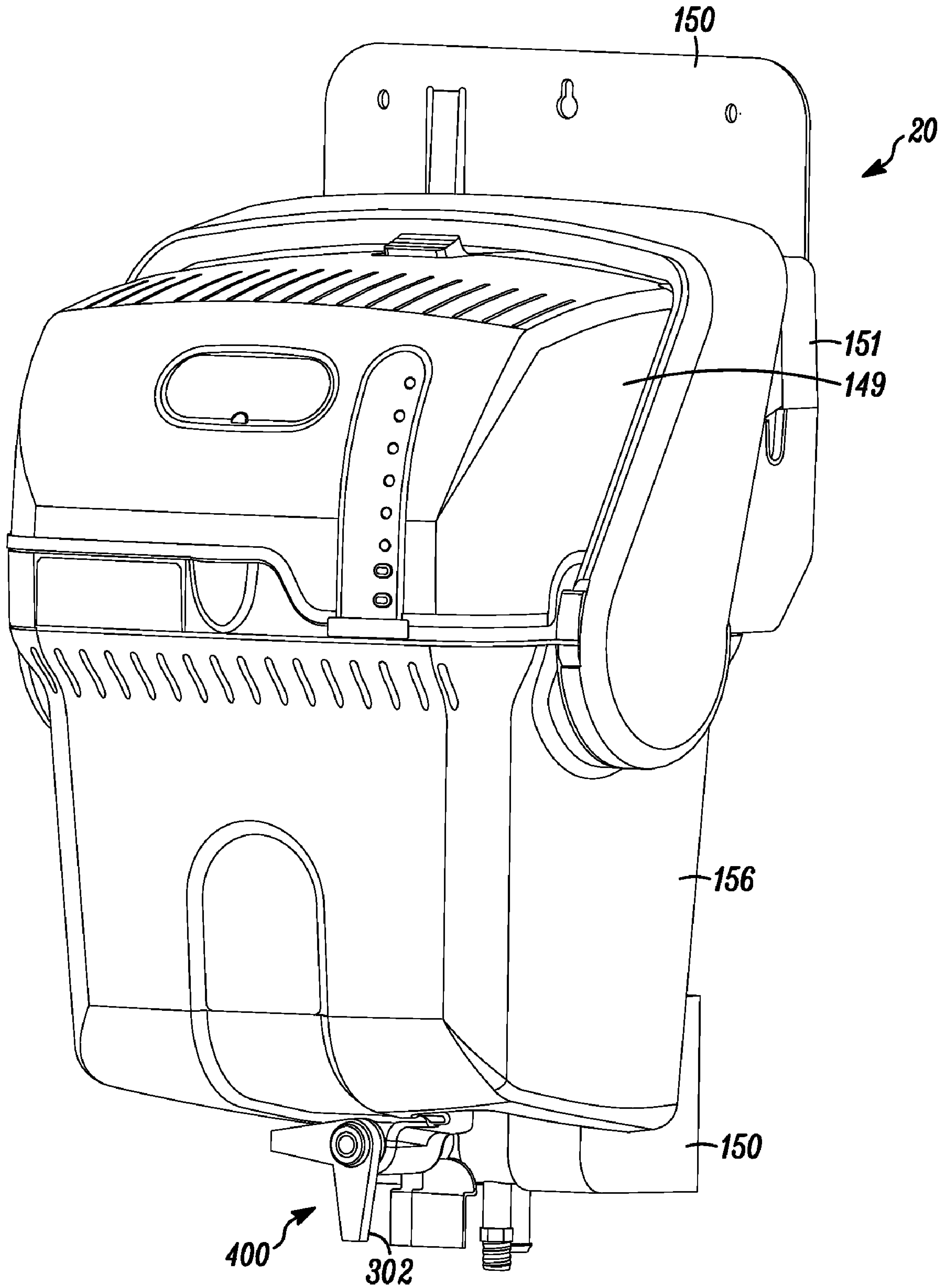
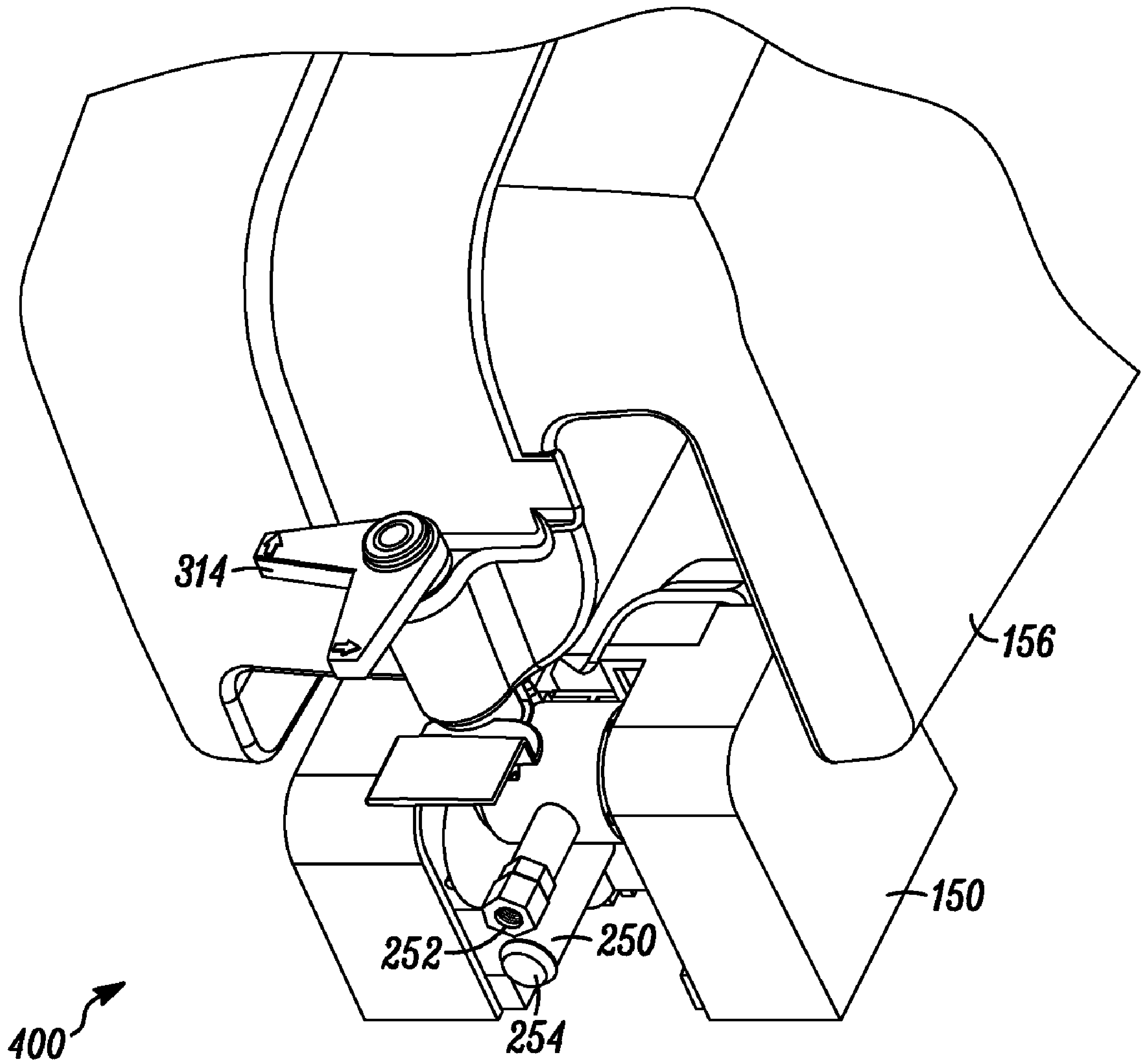


FIG. 4



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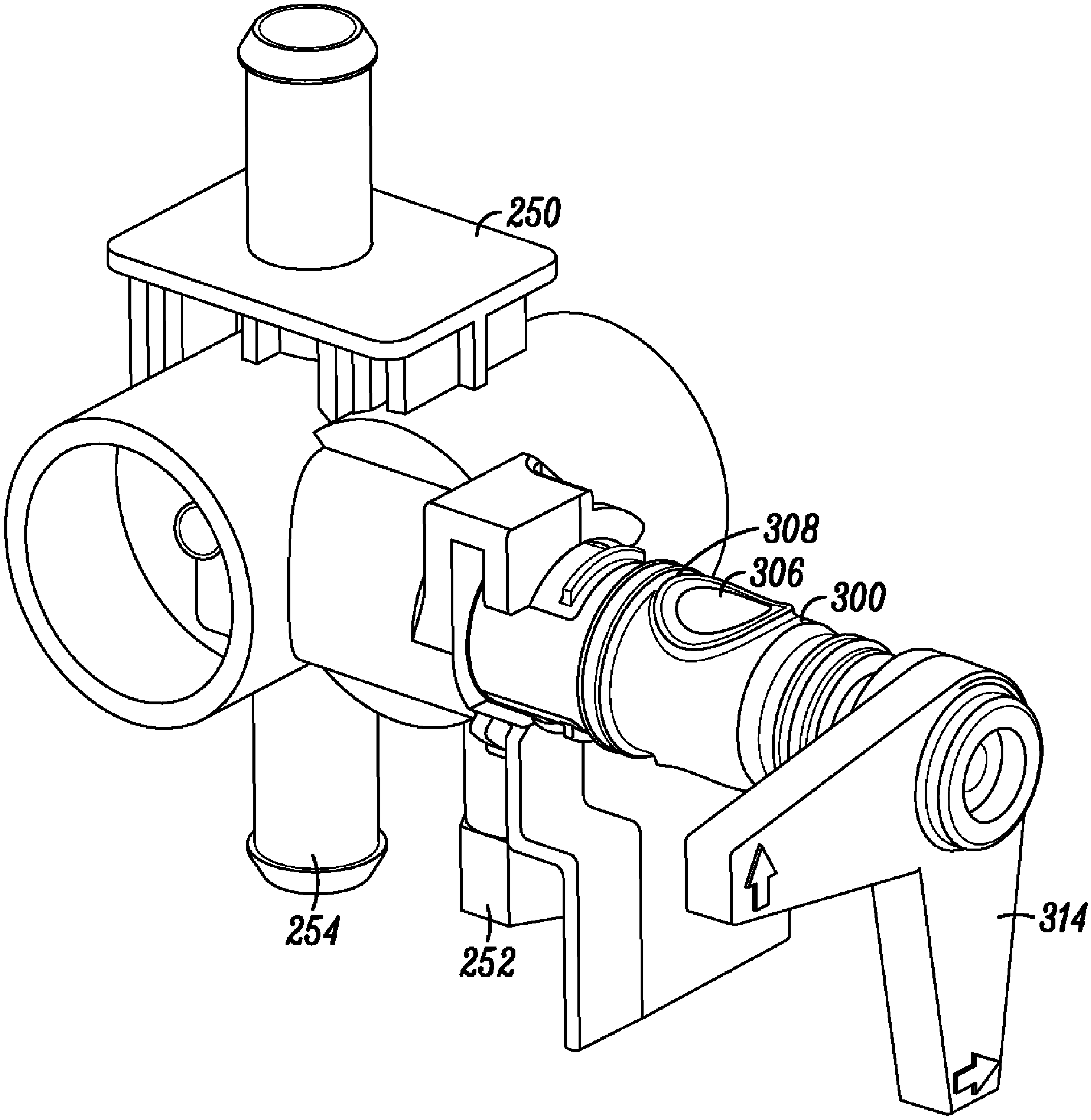

FIG. 6

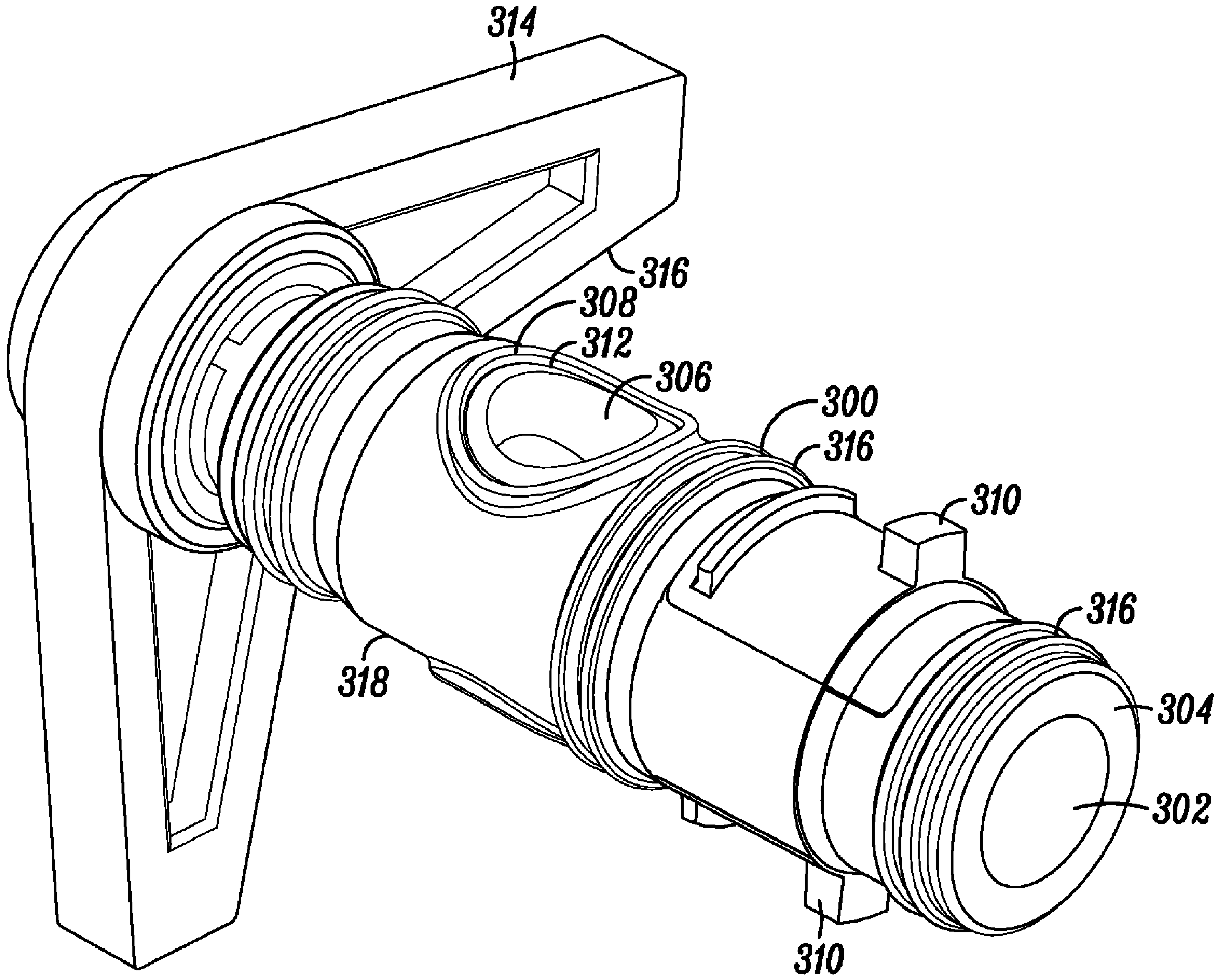

FIG. 7

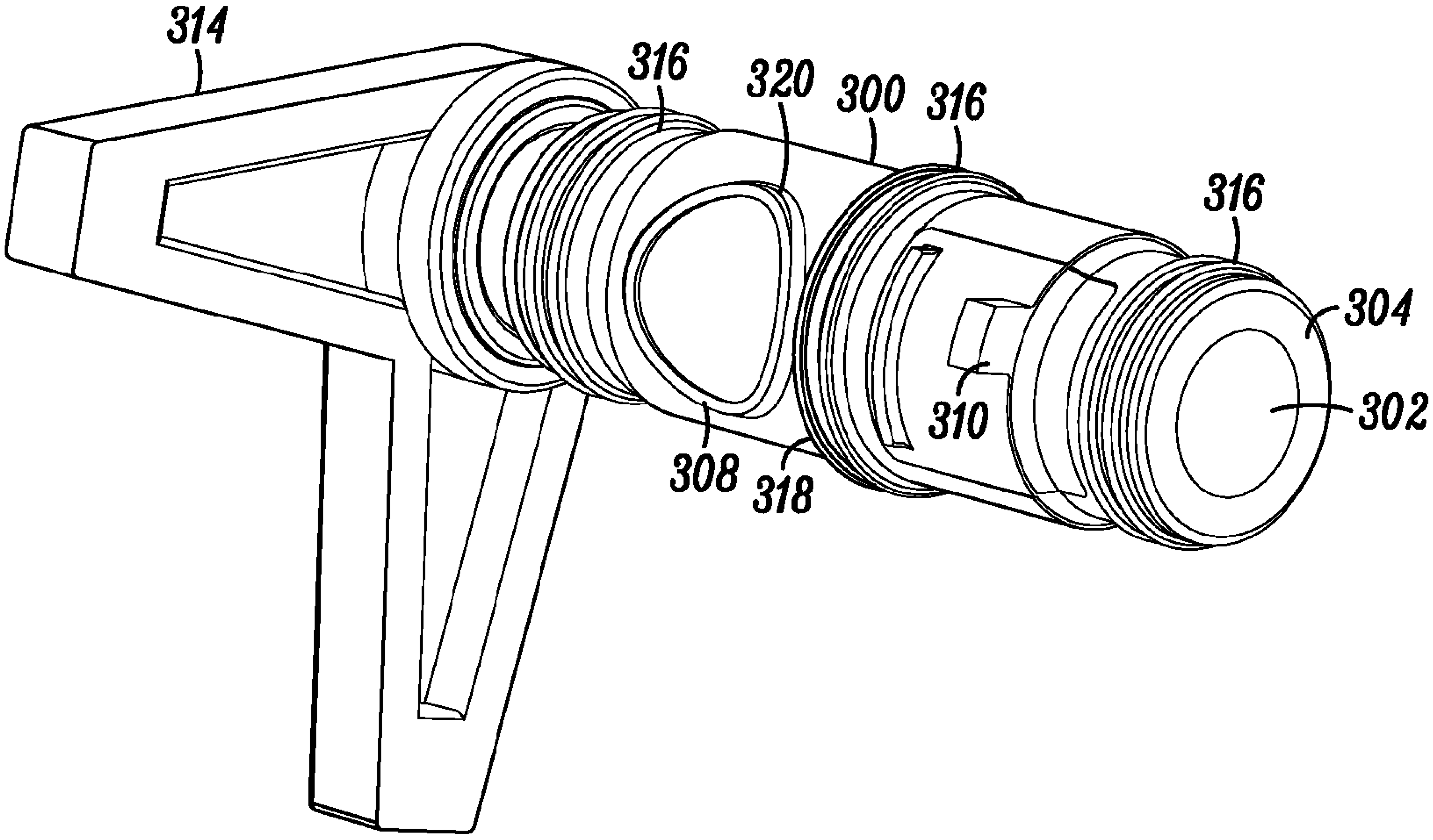
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FIG. 8

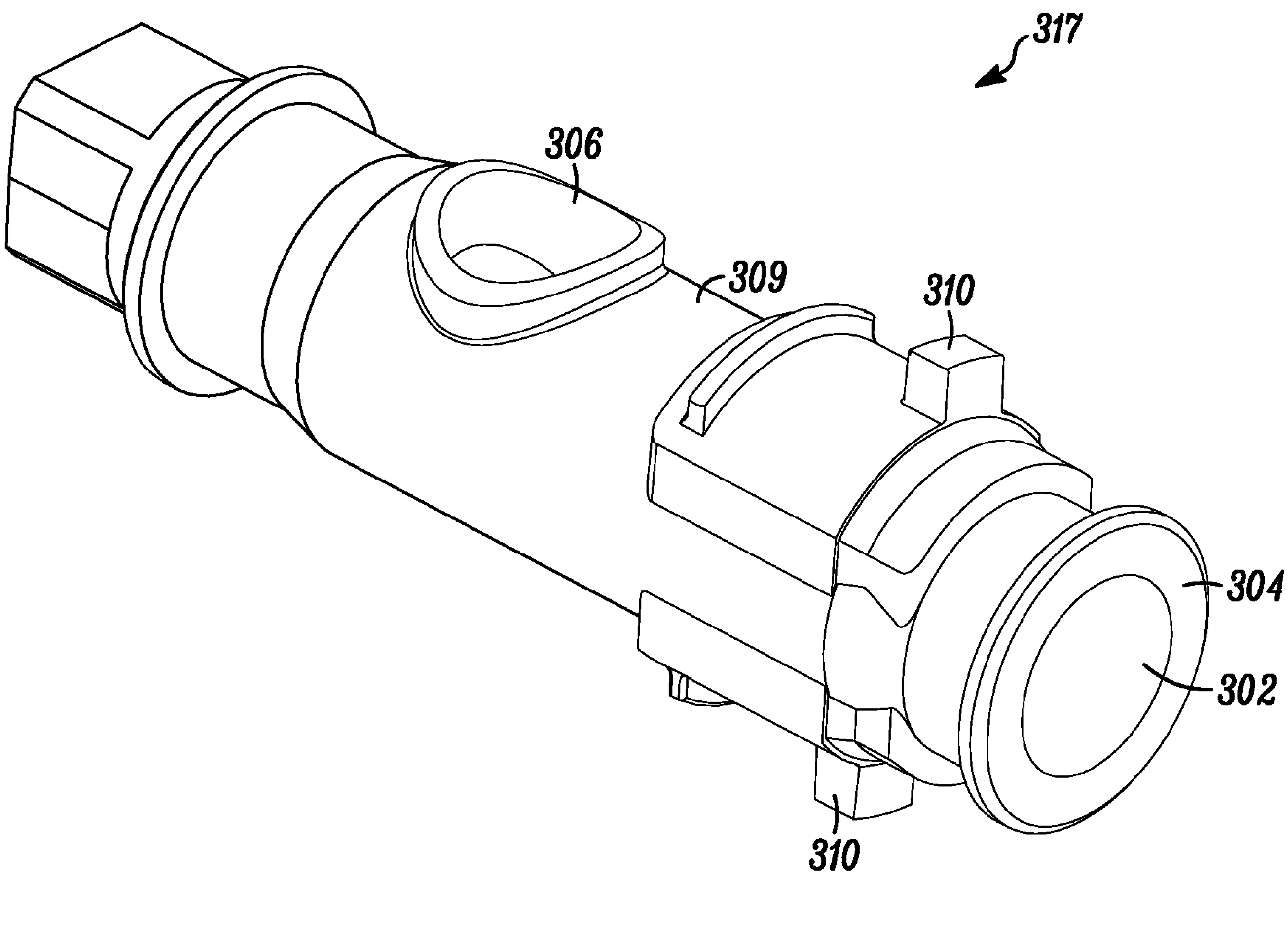
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FIG. 9

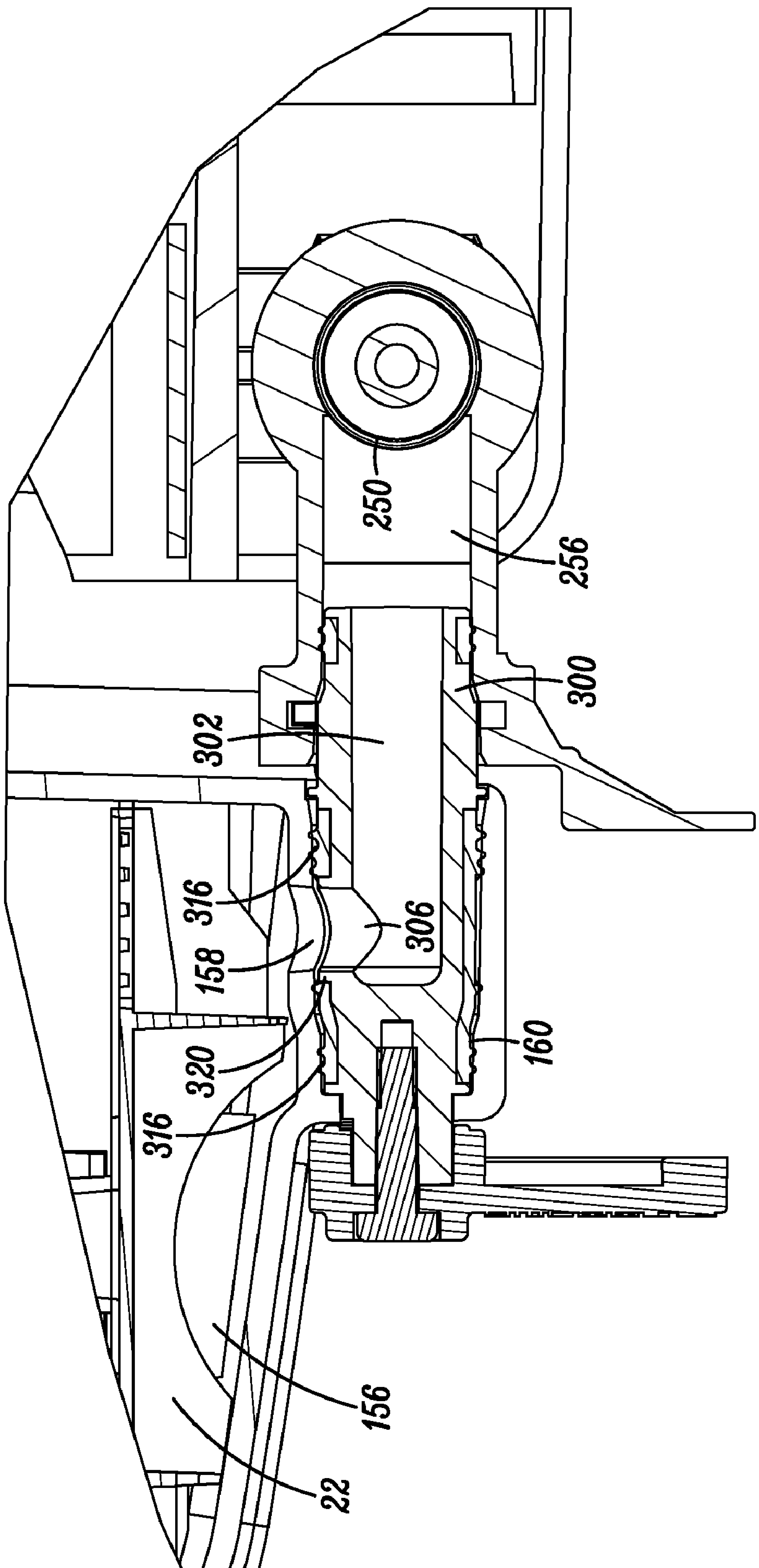

FIG. 10

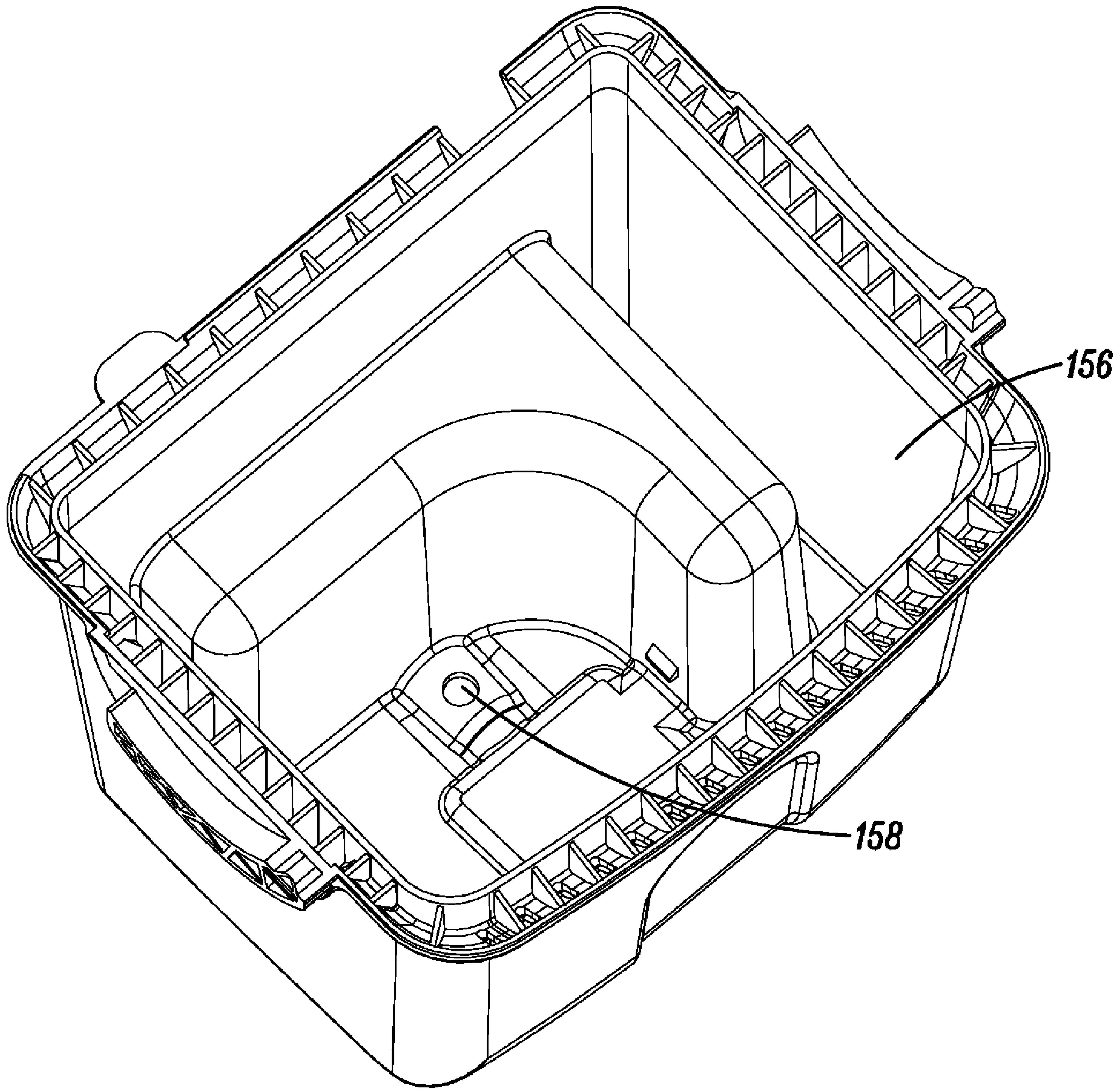

FIG. 11

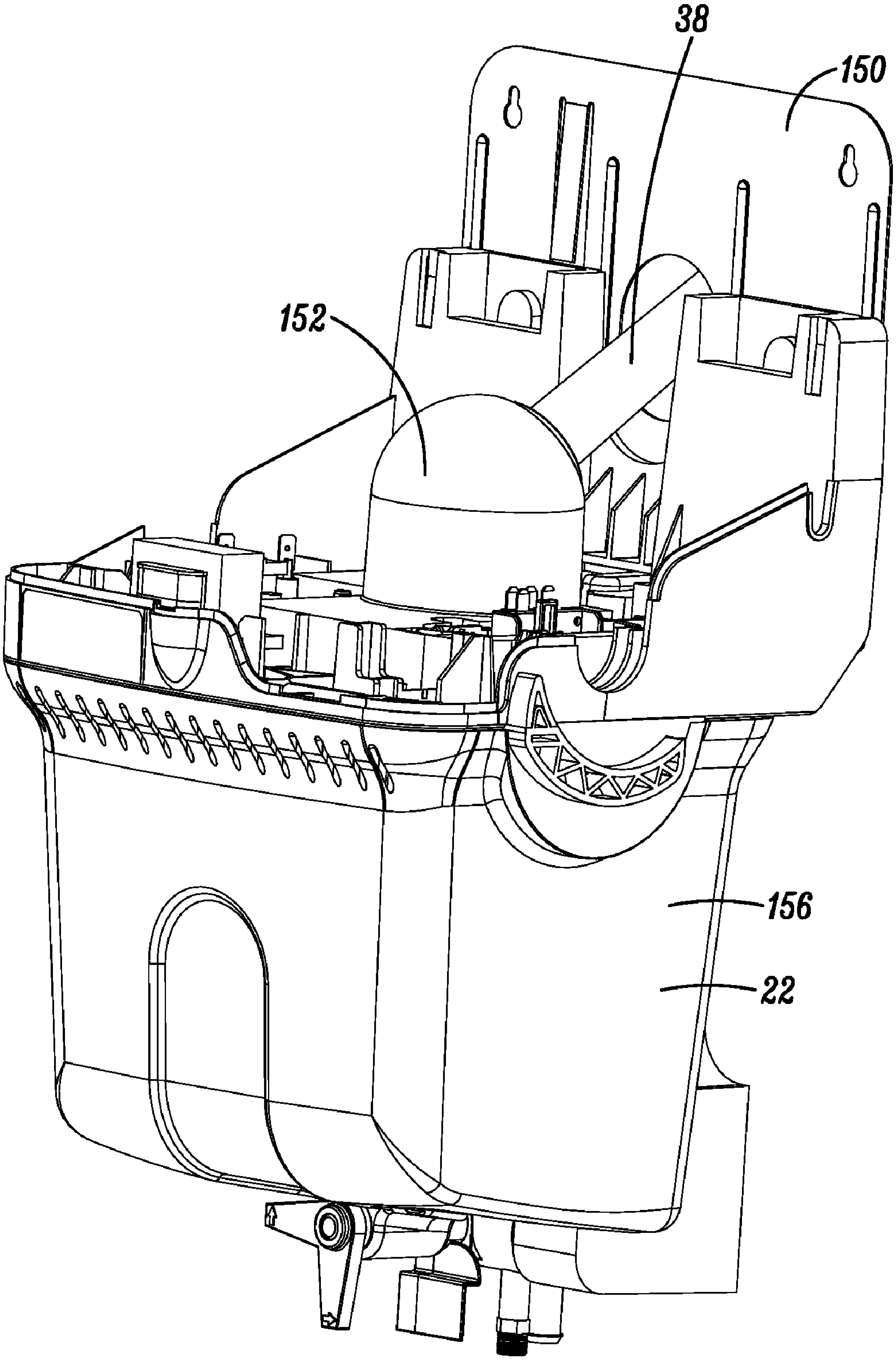

FIG. 12

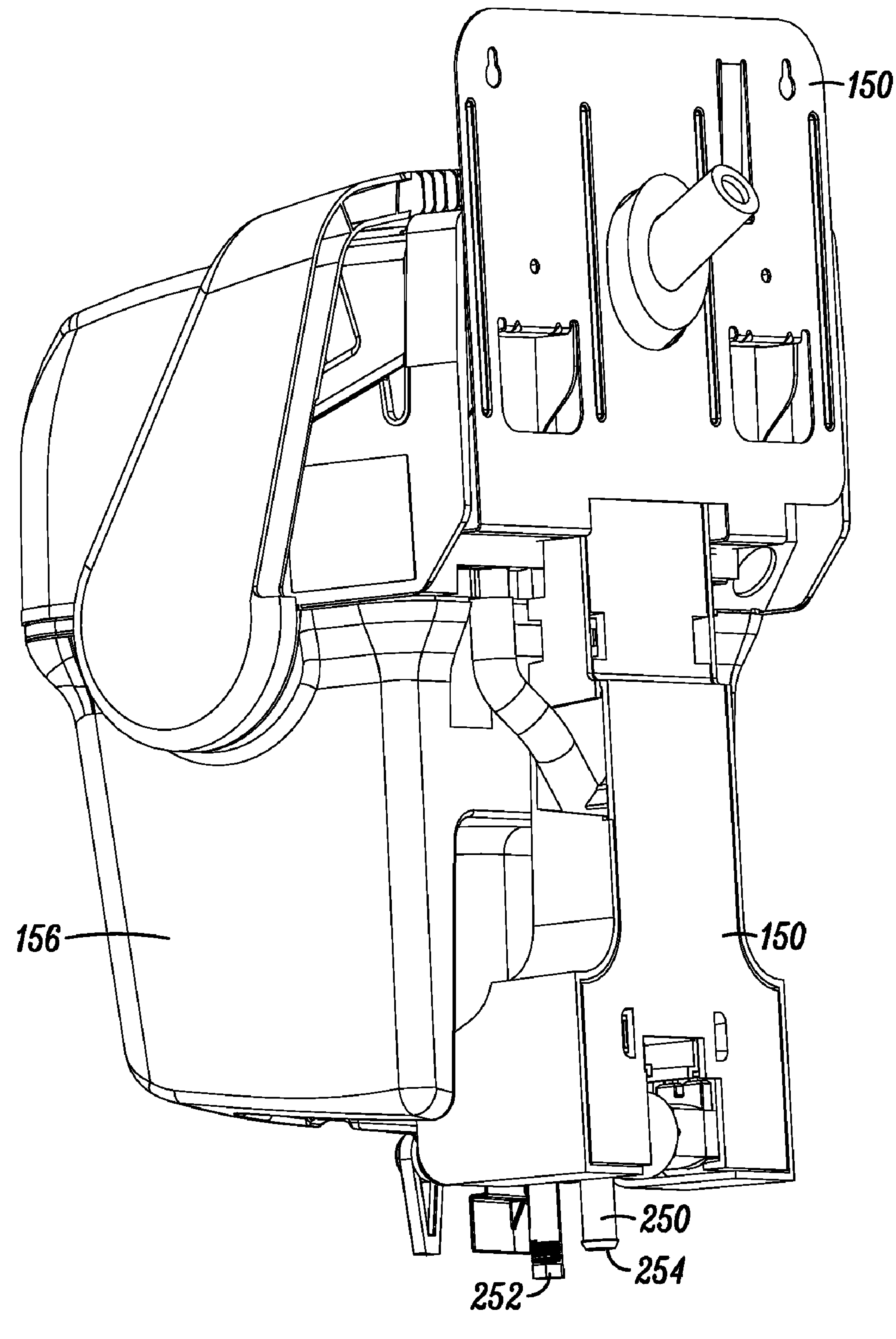

FIG. 13

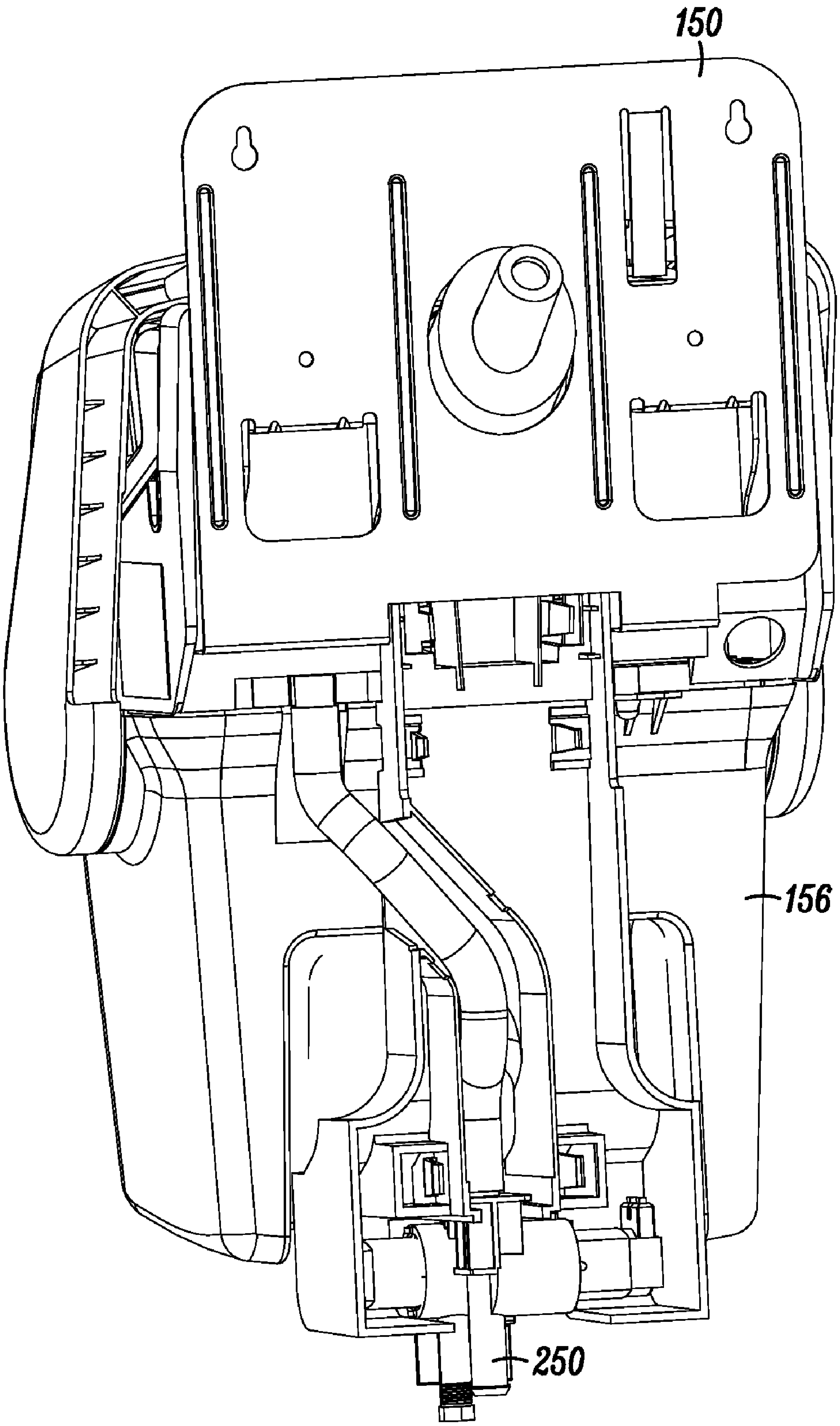

FIG. 14

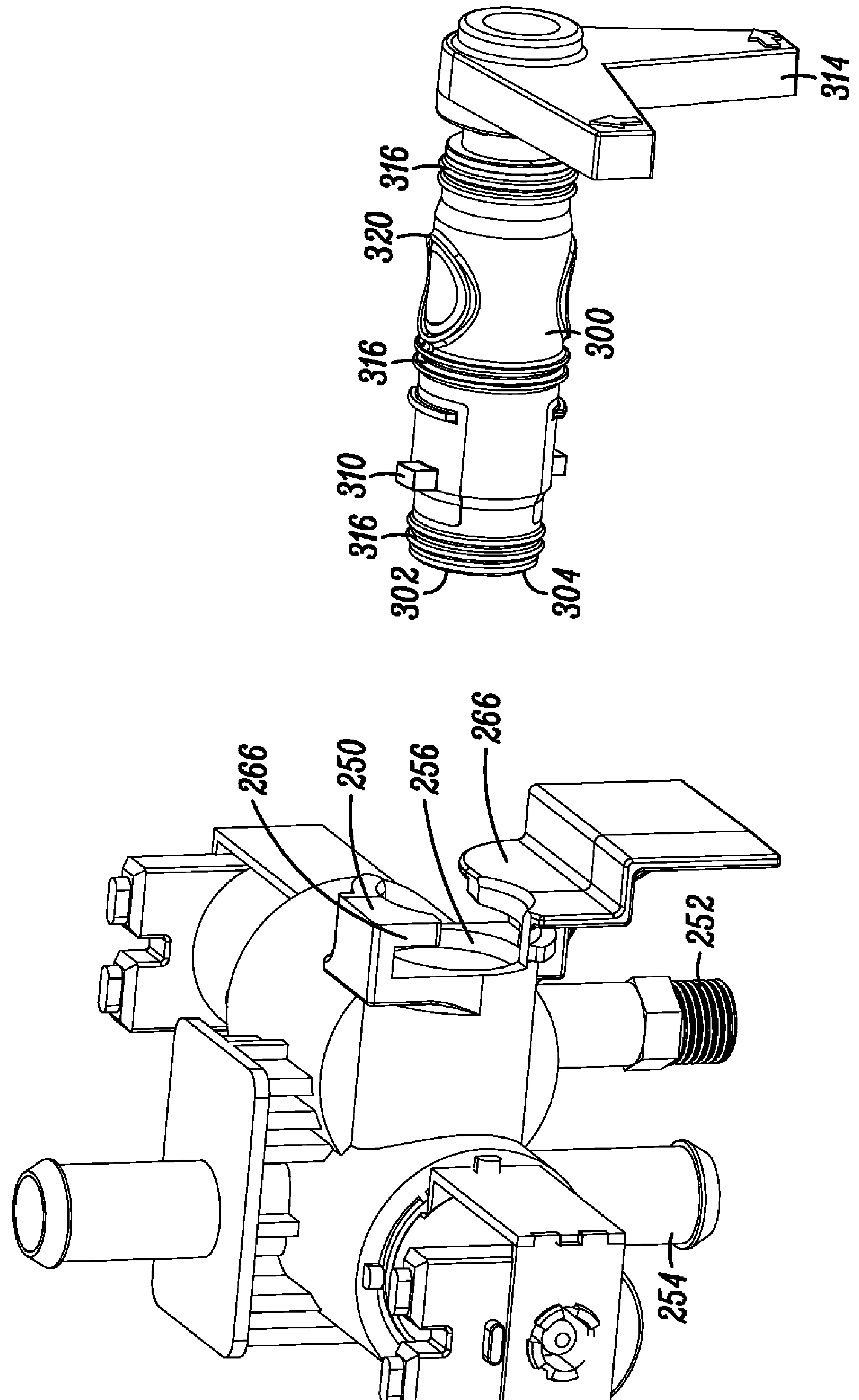

FIG. 15

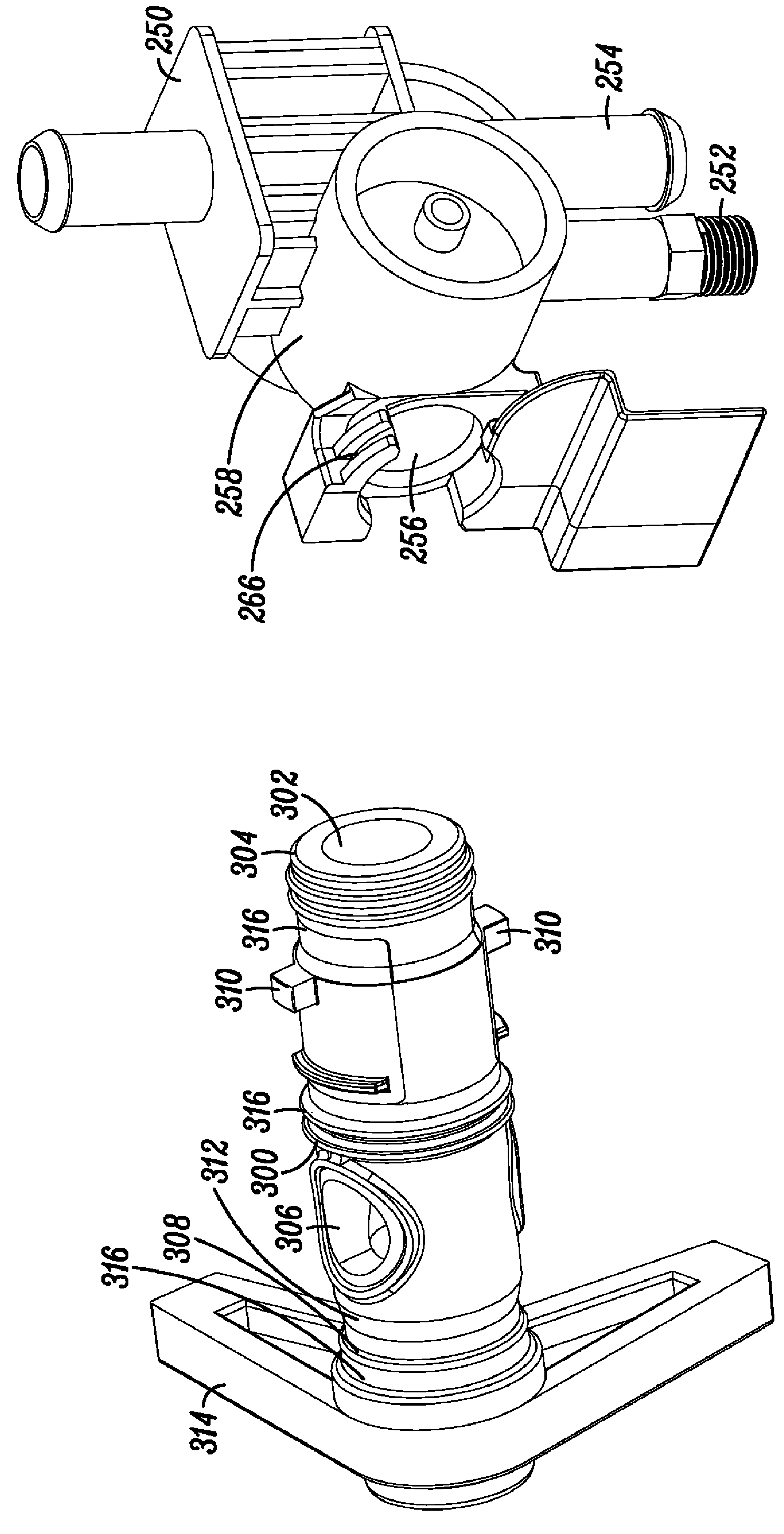
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FIG. 16

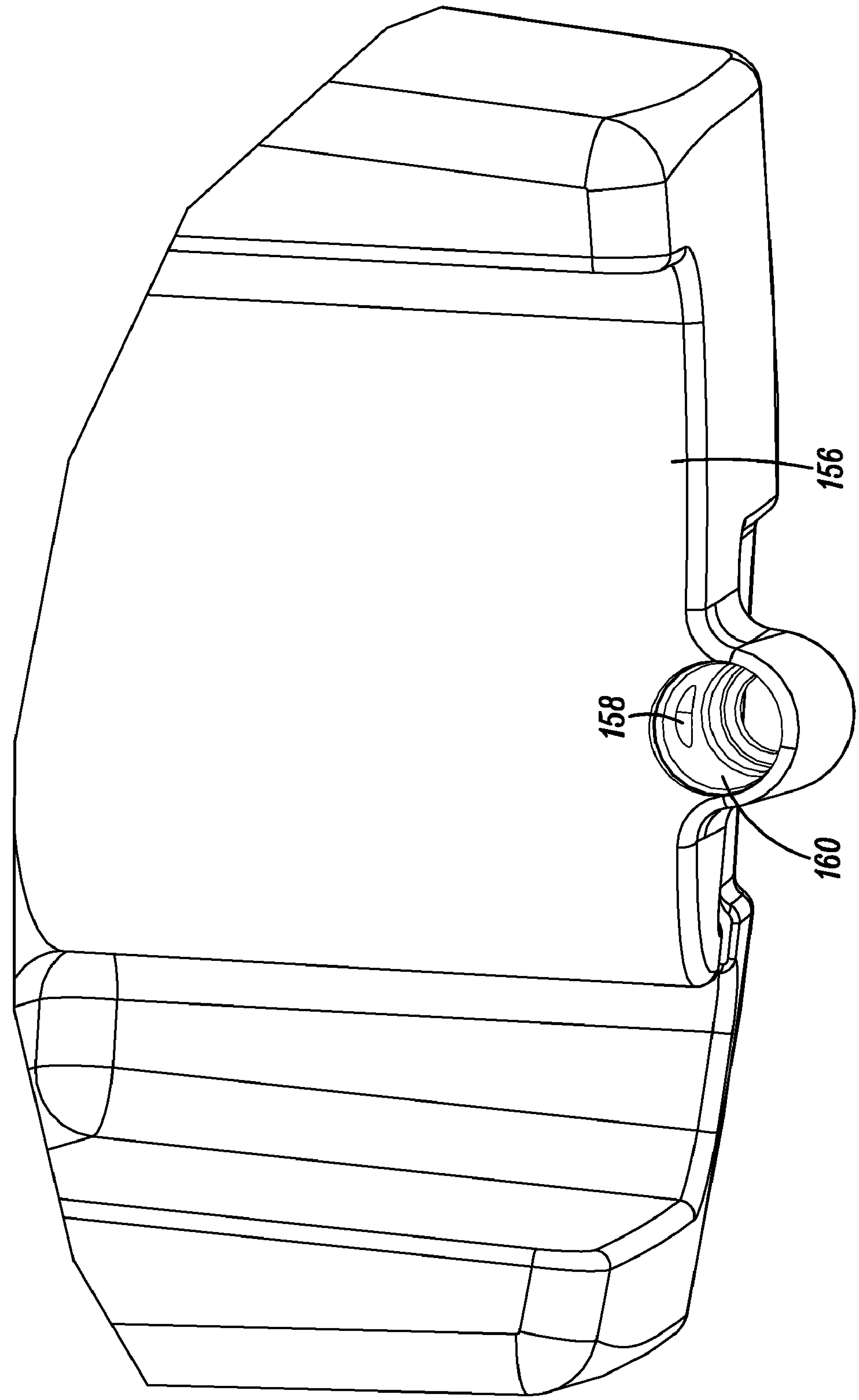

FIG. 17

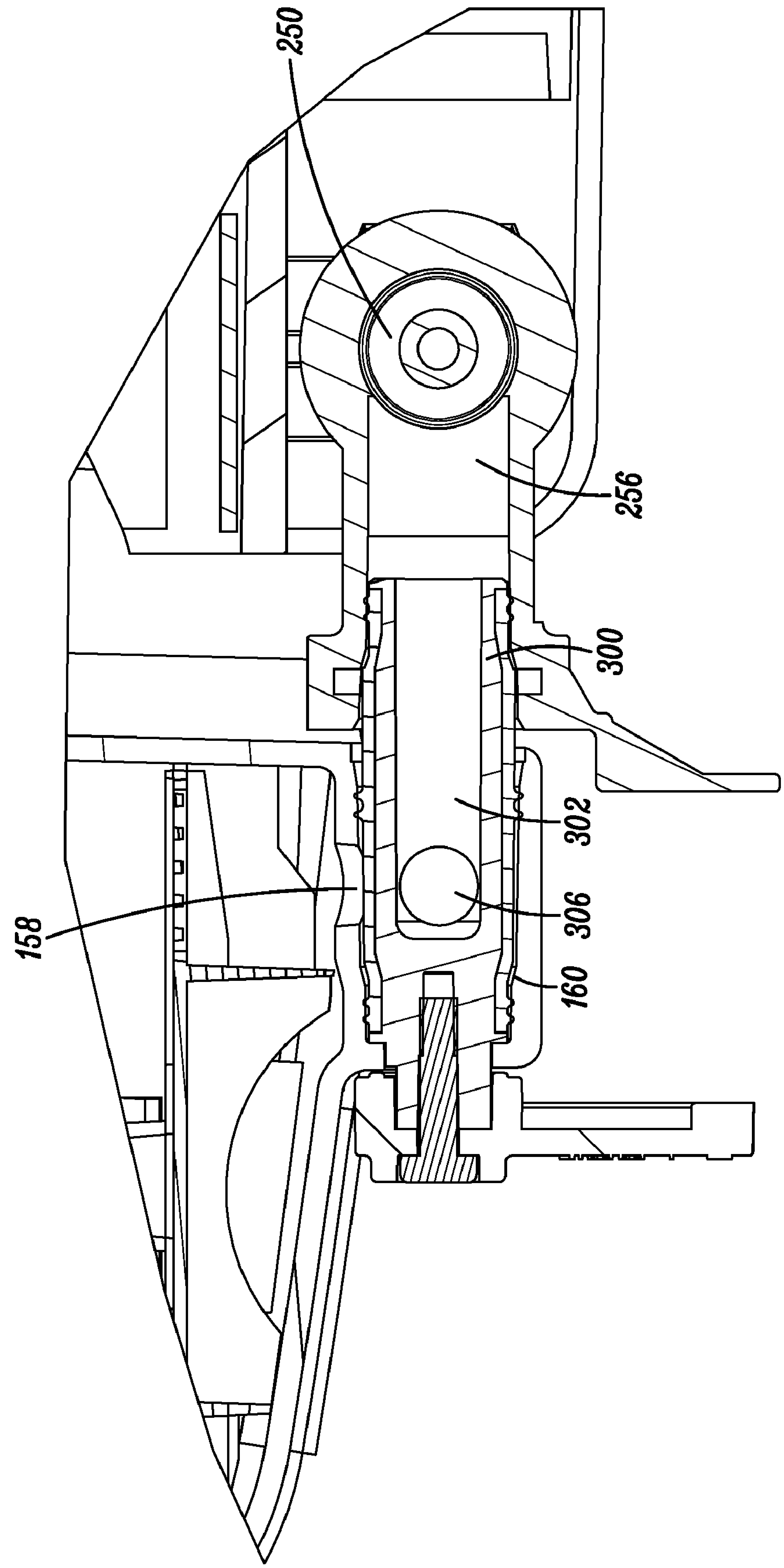

FIG. 18

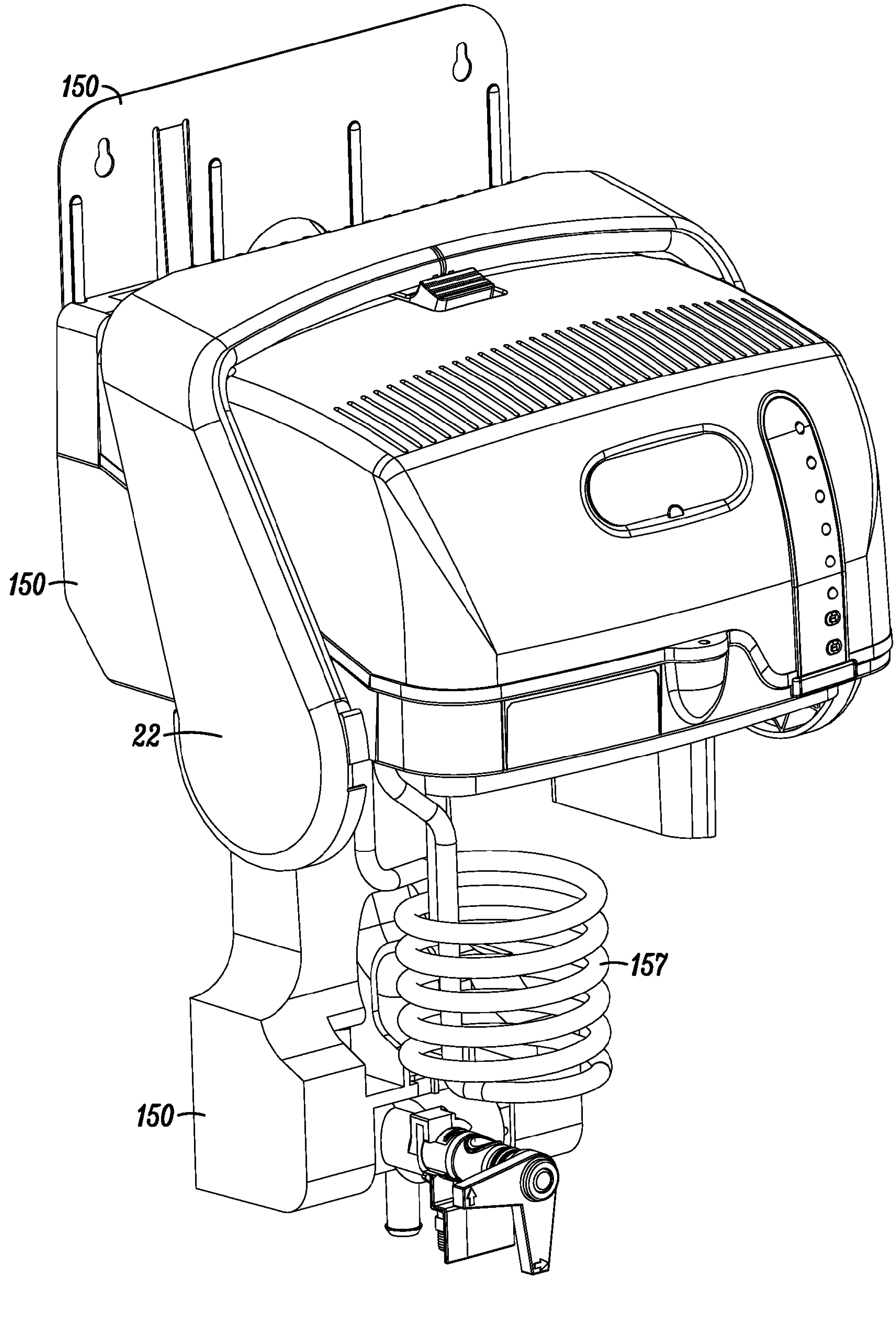

FIG. 19

STEAM HUMIDIFIER QUICK LIQUID CONNECTION

FIELD OF THE INVENTION

The invention relates to steam humidifiers, and more particularly, to constructions for a tank and liquid connections of a steam humidifier.

BACKGROUND OF THE INVENTION

The interior spaces of buildings are often at a lower than desired level of humidity. This situation occurs commonly in arid climates and during the heating season in cold climates. There are also instances in which special requirements exist for the humidity of interior spaces, such as in an art gallery or where other delicate items are stored, where it is desired that the interior humidity levels be increased above naturally occurring levels. Therefore, humidifier systems are often installed in buildings to increase the humidity of an interior space.

Humidification systems may take the form of free-standing units located within individual rooms of a building. More preferably, humidification systems are used with building heating, ventilation, and air conditioning (HVAC) systems to increase the humidity of air within ducts that is being supplied to interior building spaces. In this way, humidity can be added to the air stream at a centralized location, as opposed to having multiple devices that increase humidity at multiple points within the building interior. Additionally, because the air within ducts may be warmer than the interior space air during a heating cycle, the additional air temperature can help prevent water vapor from condensing in the vicinity of the humidifier, such as on the inside of the duct.

An issue associated with humidification system is that they should only discharge water vapor into a duct and not liquid water. Liquid water within a duct can create a number of serious problems. For example, liquid water that remains stagnant within a duct can promote the growth of mold or organisms that can release harmful substances into the air flow, potentially causing unhealthy conditions in the building. Liquid water can also cause rusting of a duct which can lead to duct failure, and can create leaks from the duct to the building interior spaces which are unsightly, can cause a slipping hazard, and can lead to water damage to the structure.

One known humidification method involves direct steam injection into an air duct of a building. This approach is most commonly used in commercial buildings where a steam boiler is present to provide a ready supply of pressurized steam. Steam humidification has the advantage of having a relatively low risk of liquid moisture entering a duct or other building space. However, pressurized steam injection systems are associated with a risk of explosion of the steam pressure vessels, as well as a risk of possibly burning nearby people, both of which are very serious safety concerns. In residential applications, there are usually no readily available sources of pressurized steam. An open bath humidifier system may be used, however these are difficult to install because they require a large hole in the duct and can only be used with horizontal or upflow ducts. Alternatively, a residential application may use direct steam injection from a separate unit to generate pressurized steam, but this separate unit is costly. Moreover, the system would suffer from the same disadvantages as are present in commercial direct steam injection systems.

One type of humidifier that is commonly used in residential applications that has the advantages of steam humidification

without the need for a separate source of pressurized steam is a tank heater type humidifier. In this type of humidifier, heat is generated within a tank of water, causing the water to boil and steam to be generated. The heat input may be any of a number of different sources, however, commonly an electrical heating element is used. One problem associated with this type of humidifier is that as water is boiled off as steam, the impurities in the water remain in the tank. These impurities generally include minerals that are naturally occurring in most sources of water. Over time, the concentration of these impurities will tend to increase in the tank, leading to greater amounts of impurities that solidify and deposit on the surfaces inside the tank. These deposits can accumulate to the point of creating numerous problems. For example, deposits on a heating coil reduce the heat transfer rate to the water, resulting in lower steam production and possibly causing overheating and failure of the coil. Deposits in the tank can clog passages where water or steam flows in or out, resulting in the failure of the humidifier. It is therefore necessary for a user of a humidifier to occasionally remove the tank of the humidifier and manually clean the tank and associated components to remove the deposits and accumulations.

Improved constructions for humidification systems are desired. In particular, improved constructions for water tanks of steam humidifiers are needed, and specifically, constructions that permit the tank to be readily removed for cleaning. For example, improved techniques and constructions are desirable to allow a water supply line and/or a water drain line to be readily removed from a tank.

SUMMARY OF THE INVENTION

The invention relates to a liquid connection feature for steam humidifiers. In one aspect, a steam humidifier is disclosed. The steam humidifier includes a tank for containing water to be heated to generate steam and a water connection manifold that has a manifold chamber in fluid communication with a water supply passage and a water drain passage. The steam humidifier further includes a rotary valve that is configured to control a fluid passage between the tank and the manifold chamber and that is further configured to control the position of one or more locking features. The rotary valve is rotatable between a first locked position and a second unlocked position. In the first locked position, the fluid passage between the tank and the manifold chamber is open and the one or more locking features are engaged with a structure of the steam humidifier. In the second unlocked position, the fluid passage between the tank and the manifold chamber is closed and the one or more locking features are disengaged from the structure of the steam humidifier.

A second aspect of the invention relates to a steam humidifier that includes a tank for containing water to be heated to generate steam, where the tank has a generally cylindrical cavity and a water passage that fluidly connects a bottom portion of the tank to the generally cylindrical cavity. The steam humidifier further includes a main structure that is configured to support the tank and a valve manifold body that is configured to be supported by the main structure. The valve manifold body defines a water supply connection, a water drain connection, a manifold chamber that includes a generally cylindrical cavity, and one or more latching features. The valve manifold body further defines a first water supply passage that fluidly connects the water supply connection to the manifold chamber, where this first water supply passage is also configured to receive a water supply control valve. In addition, the valve manifold body also defines a second water supply passage that fluidly connects the water drain connec-

tion to the manifold chamber, where this second water supply passage is also configured to receive a water drain control valve. The steam humidifier also includes a rotary spool valve that is generally cylindrical and is positioned at least partially within the generally cylindrical cavity of the manifold chamber and at least partially within the generally cylindrical cavity of the tank. The rotary spool valve defines an axial fluid passage that intersects with an end surface of the rotary spool valve, and a radial fluid passage that intersects with a radial surface of the rotary spool valve and that is configured to be in fluid communication with the manifold chamber through the axial fluid passage. The rotary spool valve also defines one or more latching tabs that are configured to engage the one or more latching features of the valve manifold body, and one or more seals that are positioned about the intersection of the radial fluid passage with the radial surface of the rotary spool valve. The steam humidifier further includes a handle secured to an end of the rotary spool valve.

Another aspect of the invention relates to a method of removing a tank of a steam humidifier. The method includes closing one or more valves in a valve manifold body to isolate a water supply and a water drain from a manifold chamber of the valve manifold body. The method further includes rotating a handle attached to a rotary spool valve to cause a fluid passage leading from the tank to the manifold chamber of the valve manifold body to be blocked and causing locking features of the rotary spool to disengage from a supporting structure of the steam humidifier. Furthermore, the method includes removing the tank and the rotary spool valve from the supporting structure.

The invention may be more completely understood by considering the detailed description of various embodiments of the invention that follows in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a cross-sectional view of a tank heater type steam humidifier.

FIG. **2** is a schematic representation of an HVAC system having a humidifier.

FIG. **3** is a schematic representation of a control system of a humidifier.

FIG. **4** is a front perspective view of a humidifier having a water tank with a quick liquid connection feature constructed according to the principles of the present invention.

FIG. **5** is a perspective view of a lower portion of the humidifier of FIG. **4**.

FIG. **6** is a perspective view of a multi function valve tank interlock assembly, including a rotary spool valve and a valve manifold body, configured to provide for readily disassembleable liquid connections to a tank of a humidifier.

FIG. **7** is a perspective view of a rotary spool valve of the multi function valve tank interlock assembly of FIG. **6**.

FIG. **8** is an alternate perspective view of the rotary spool valve of FIG. **7**.

FIG. **9** is a perspective view of a rotary spool valve body of FIG. **7** without a sleeve.

FIG. **10** is a cross-sectional view of a humidifier tank having a rotary spool valve within a cylindrical cavity of a valve manifold.

FIG. **11** is a top perspective view of an open top container of a humidifier configured for use with the quick liquid connection feature of FIGS. **4** to **10**.

FIG. **12** is a front perspective view of a humidifier having various components removed to show details.

FIG. **13** is a rear perspective view of a steam humidifier.

FIG. **14** is a rear perspective view of a steam humidifier having components removed to show details.

FIG. **15** is a perspective exploded view of the multi function valve tank interlock assembly of FIG. **6**, including the valve manifold body and rotary spool valve.

FIG. **16** is another perspective exploded view of the multi function valve tank interlock assembly of FIG. **6**.

FIG. **17** is a view of a cylindrical cavity in a tank configured to receive a rotary spool valve.

FIG. **18** is a cross-sectional view of a humidifier tank having a rotary spool valve within a cylindrical cavity of a valve manifold.

FIG. **19** is a front perspective view of the main structure of the humidifier, with an open top container part of the tank removed to show details.

While the invention may be modified in many ways, specifics have been shown by way of example in the drawings and will be described in detail. It should be understood, however, that the intention is not to limit the invention to the particular embodiments described. On the contrary, the intention is to cover all modifications, equivalents, and alternatives following within the scope and spirit of the invention as defined by the claims.

DETAILED DESCRIPTION OF THE INVENTION

As described above, minerals, sediments, and other impurities present in water tend to deposit in the tank of a tank heater type humidifier over the course of its operation. These deposits can build up and cause damage and interfere with the proper functioning of the humidifier. The rate at which these deposits form depend on a number of variables, including the mineral content of the water (hardness) and the amount of time that the humidifier is operated. It is generally recommended or required that the user of a humidifier disassemble and manually clean the tank and associated parts at a regular interval, such as every year. In some cases, a humidifier may provide an indication to the user that the tank needs to be cleaned, such as a visual indication or an audible indication. It is therefore that the user of a humidifier remove the tank at regular intervals and manually clean it to remove the deposits and accumulations.

An embodiment of a tank heater type humidifier is depicted schematically in FIG. **1**. Humidifier **20** includes a tank **22** configured to retain a volume of liquid water. Tank **22** is generally constructed out of material that is sufficiently resistant to high temperatures, such as the temperature of boiling water. Examples of suitable materials for tank **22** are temperature resistant plastics, an example of which is a thermoplastic resin such as a polyphenylene ether/polystyrene blend, and stainless steel. A heating coil **24** is also provided to heat water within tank **22**. Heating coil **24** is generally an electric heating coil that generates heat when an electric current is passed through a resistive material. However, other types of heating coils **24** are usable. For example, heating coil **24** could pass a heated material such as a heated liquid through a tube that allows heat to transfer to the liquid in the tank **22**. Furthermore, a heater may be substituted for heating coil **24**, where a heater is of a conventional liquid heating design, such as a propane or natural gas liquid heater or a fuel oil burner. In other embodiments, heating coil **24** may function by passing an electric current through the water to generate heat.

Tank **22** is shown in FIG. **1** as having an isolated chamber **26** that is separated from a main chamber **30** of tank **22** by baffle **28**. Isolated chamber **26** is in fluid communication with main chamber **30** by way of opening **32** which allows liquid from main chamber **30** to flow into isolated chamber **26** and to reach the same fluid level as in main chamber **30**. In some embodiments, isolated chamber **26** includes a vent from an upper portion of the isolated chamber **26** to an upper portion of the main chamber **30** to prevent excessive or irregular pressure build-up in the isolated chamber, which could in turn cause erratic or inaccurate water level sensing in the isolated chamber **26**. Isolated chamber **26** tends, however, to be insulated from ripples, bubbles, and other fluctuations of the water level in main chamber **30**, and therefore is a suitable location for measuring the water level in tank **22**. FIG. **1** also shows that a high level water sensor **34** and a low level water sensor **36** are present within isolated chamber **26**. Sensor **36** detects the presence of water at a first level and sensor **34** detects the presence of water at a second level, where the first level is lower than the second level. Each of sensors **34**, **36** is configured to detect the presence of water at the particular sensor. Sensors **34**, **36** may be a current-detection type of sensor, where a source of current such as low voltage alternating current is applied at a point in the tank that is below both sensors **34**, **36** and where sensors **34**, **36** are configured to detect the presence of current which indicates a current path from the source of current, through the water, to sensors **34**, **36**. Humidifier **20** further includes a tube **38** that projects from main tank chamber **30** to the interior of an air duct **40** and that provides a fluid connection for the flow of steam from main tank chamber **30** to the interior of air duct **40**.

Humidifier **20** includes a fill valve **42** and a drain valve **44**. Fill valve **42** is in fluid communication through conduit **54** with a water supply **46**, such as a municipal water supply system or a well pump system. Drain valve **44** is in fluid communication through a conduit **56** with a water receiving system **48**, such as a municipal water treatment system, a septic system, or a drain field. Humidifier **20** further includes a controller **52** that is in communication with water level sensors **34**, **36** and has the ability to control the fill and drain valves **42**, **44**. Controller **52** also includes one or more timers configured to measure elapsed times.

A typical heating, ventilation, and air conditioning (HVAC) installation that includes a humidifier is depicted in FIG. **2**. Conditioned space **200** of a building is configured to receive conditioned air from supply duct **202** and to provide for return air flow through return duct **204**. Conditioned space **200** includes at least one thermostat **206** that is in communication with conditioning device **208**. Conditioning device **208** may be a furnace, a boiler, an air conditioner, a heat exchanger, or a combination thereof, that is configured to condition return air from return duct **204** and deliver the conditioned air to supply duct **202**. Conditioning air may involve increasing the temperature of the air, decreasing the temperature of the air, cleaning the air, or other such processes. Conditioning device **208** generally includes a fan or blower for drawing air from return duct **204** and delivering air through supply duct **202**. Thermostat **206** senses the temperature in conditioned space **200** and activates conditioning device **208** when the temperature deviates from a set value. When conditioning device **208** is activated by a call for conditioning from thermostat **206**, conditioned air is supplied through supply duct **202** to adjust the temperature of conditioned space **200** until the temperature sensed by thermostat **206** satisfies a set value. In some embodiments, thermostat **206** may be configured to receive an input to run a fan or blower without temperature conditioning of the air. In this case only the fan or blower portion of conditioning device **208** is activated and air is supplied through supply duct **202** without being conditioned by conditioning device **208**.

FIG. **2** also shows a typical installation of humidifier **20**. Humidifier **20** is installed on supply duct **202** downstream of conditioning device **208**. A humidistat **210** is installed in conditioned space **200** or within return duct **204** and is in communication with humidifier **20**. One embodiment of a humidistat **210** senses the relative humidity level (RH) present in conditioned space **200** and activates humidifier **20** when the humidity level falls below a set value. Other embodiments of humidistat **210** sense indoor dewpoint or even outdoor dewpoint in combination with either indoor RH or indoor dewpoint. In some embodiments, the thermostat **206** will incorporate the functionality of humidistat **210**. When humidifier **20** is activated, humidity is added to conditioned air within supply duct **202** in order to increase the humidity in conditioned space **200**. In some embodiments, humidifier **20** and/or humidistat **210** are configured to activate humidifier **20** only when conditioning device **208** is activated. This ensures that air is flowing through supply duct **202** to carry the additional humidity to conditioned space **200**. If humidifier **20** is activated without air flowing in supply duct **202**, the additional humidity provided by the humidifier may condense on the walls of the duct and cause damage, and the additional humidity will also not be effectively delivered to conditioned space **200**. In other embodiments, the conditioning device **208** will be activated any time there is a demand for humidification from humidistat **210**.

In operation of humidifier **20**, when there is a call for humidification, humidifier **20** is filled by opening fill valve **42** to allow water from supply **46** to flow through conduit **54** into main chamber **30** of tank **22** and to isolated chamber **26**. Fill valve **42** will remain open until water is detected at high water sensor **34**, at which point fill valve **42** is closed. In some embodiments, an overfull sensor is provided that detects the presence of water above high water sensor **34**, in which case fill valve **42** is closed. Heating coil **24** is then energized, causing the temperature of the water in tank **22** to increase in temperature. In some embodiments, water tank **22** is filled prior to there being a demand for humidification, such as at installation or system start-up, and then waits for a call for humidification to energize the heating coil **24**. As the water in tank **22** is heated, the water in tank **22** will begin to boil and steam will form at the top **50** of tank **22**. A very slight pressure will be established in the top area **50** of tank **22**, driving steam through tube **38** and into duct **40**. Tube **38** is configured to allow sufficient steam to flow into duct **40** that very little pressure will build in tank **22**. In other embodiments, no pressure or absolutely minimal pressure builds in tank **22** and steam is carried by convection into duct **40**. The steam enters the air in duct **40** where it is carried to conditioned spaces within a building. As water is converted to steam, the water level in tank **22** will decrease. With sufficient operation, the water level will drop below the height of low water sensor **36**. When water falls below the height of low level sensor **36**, fill valve **42** will be opened and remain open until water reaches high level sensor **34**.

An embodiment of the components of a control system of humidifier **20** is depicted in FIG. **3**. As shown in FIG. **3**, controller **52** is in communication with high level sensor **34** and low level sensor **36**. Controller **52** therefore receives signals representative of whether the water level in tank **22** is at or above low level sensor **36** and whether the water level in the tank **22** is at or above high level sensor **34**. Controller **52** is further in communication with fill valve **42** and drain valve **44**, and is able to control the operation of each. Controller **52** is also shown in FIG. **3** as being in communication with indicator **58**. Indicator **58** may be used to communicate information to a user, such as the need to clean the tank. Controller **52** also has an input element **60** such as a switch or button configured to receive input from a user, such as to indicate that the humidifier has been cleaned.

In use, tank **22** is preferably connected to a source of liquid water, such as a municipal water system or a well system, in order to provide the water that will be converted to steam to provide humidity. Tank **22** is also preferably connected to a liquid water drain, such as a municipal sewer system or a septic system, to allow the tank to be drained occasionally. A quick liquid connection feature constructed according to the principles of the present disclosure allows the tank to be readily serviced without requiring the removal of the individual liquid connections or requiring the use of tools. FIG. **4** is a front perspective view of a humidifier having a tank with a quick liquid connection feature **400** that allows the tank to be removed for cleaning in an expedient manner that does not require special tools or training. A close up of quick liquid connection feature **400** is shown in FIG. **5**. This arrangement allows the tank to be removed without the user having to individually disconnect the water supply line and the water drain line. This is particularly advantageous because the typical humidifier user who has to remove the tank for cleaning is a homeowner who does not have special training, may not want to spend much time learning how to perform a procedure to remove the liquid connections from a tank, and may not have ready access to tools for removing the liquid connections from a tank.

The humidifier **20** depicted in FIG. **4** includes a main structure **150** that is configured to be mounted to a duct or other attachment point within a building. Main structure **150** may consist of a single piece or may be formed from several pieces that are attached or secured to each other. Details of main structure **150** and associated components are shown in FIG. **12** where certain components are removed for clarity. Compared to FIG. **4**, a cover **149** and handle **151** are not shown in FIG. **12**. In one embodiment, main structure **150** and associated components are formed by injection molding. Main structure **150** also includes a structure for receiving steam tube **38**, such as a steam dome **152**, such that steam tube **38** is in fluid communication with tank **22**. Tank **22** is partially defined by main structure **150** that forms an upper boundary of tank **22**, and the remainder of tank **22** is defined by open top container **156**. Open top container **156** is assembled to main structure **150** to form a watertight and steamtight enclosed volume that constitutes tank **22**.

The steam humidifier depicted in the figures includes a tank for containing water to be heated to generate steam. In some embodiments, an electrical resistance heater element is positioned in the tank for heating the water to generate steam, such as element **24** depicted in FIG. **1**. In the embodiment of FIGS. **4-19**, an electrical resistance heater is integral with the main structure **150**. The main structure **150** is shown in FIG. **19** without the open top container **156**. The main structure **150** includes heating element **157**. As mentioned, in some embodiments, at least a portion of the tank is formed from a main structure **150** of the humidifier. The main structure **150** is also configured to support the weight of the steam humidifier and is generally not removed once it is installed. The weight of the tank **22**, including the weight of the water contained within the tank **22**, is generally transferred to the main structure **150**. However, as discussed above, it is normally required that the interior of the tank **22** be cleaned at regular intervals to remove deposits that tend to form in the tank **22** when the water is boiled off as steam. To assist with accomplishing this, the open top container **156** is configured to be removed from the main structure **150**. One example of a tank latching configuration that allows removal from the rest of the humidifier structure for easy cleaning of the tank is described in co-pending U.S. patent application Ser. No. 11/873,783, titled "Humidifier with Water Tank Quick Assembly Feature," filed on the even date herewith, which is hereby incorporated herein by reference.

An embodiment of an open top container **156** is shown in FIG. **11**. Open top container **156** has a water passage **158** at the bottom of the container **156**. As shown in FIG. **17**, this water passage **158** is in fluid communication with a cylindrical cavity **160** that is integral with the open top container **156**. The cylindrical cavity **160** is configured to receive at least a portion of a rotary spool valve, and as such is open at both ends. A cross section of the rotary spool valve **300** within the cylindrical cavity **160** in the open top container **156** is shown in FIG. **10**.

A valve manifold body **250** is supported by, or attached to, the main structure **150**. An embodiment of the valve manifold body **250** is shown in FIGS. **15** and **16**. The valve manifold body **250** is shown assembled to the humidifier in FIGS. **5**, **13**, and **14**. Specifically, the valve manifold body **250** is secured or attached to the main structure **150**. A cross section of the valve manifold body **250** and the tank **22** is shown in FIG. **10** (along with other components to be discussed below). As seen in FIGS. **15** and **16**, the valve manifold body **250** defines a water supply connection **252**. The water supply connection **252** is generally connected to a supply of water, such as a municipal water supply system or a well system. The valve manifold body **250** also has a water drain connection **254**, where the water drain connection **254** is generally connected to a water receiving system, such as a municipal waste water system or a septic or drain field system.

The valve manifold body **250** includes a manifold chamber **256** that generally constitutes a cylindrical cavity. There is a first water supply passage **258** (FIG. **16**) that fluidly connects the water supply connection **252** to the manifold chamber **256**. As shown in FIG. **16**, the first water supply passage **258** is configured to receive a water supply control valve (not shown) that controls the flow of water within the first water supply passage **258**. For example, the water supply control valve may be a solenoid valve that receives an electrical signal from a controller to cause a valve seat to move towards and away from the supply passage **258**. Other types of valves are usable. For example, pneumatic valves or manual valves may be used. There is also a second water supply passage **260** (FIG. **15**) that fluidly connects the water drain connection **254** to the manifold chamber **256**. In the depicted embodiments, the second water supply passage **260** is on an opposite side of the valve manifold body **250** from the first water supply passage **258**. However, the second water supply passage **260** can be positioned in other locations. This second water supply passage **260** is also configured to receive a water drain control valve that controls the flow of water within the second water supply passage **260**.

The valve manifold body **250** also includes one or more grooves **266** or similar features that are configured to receive one or more corresponding latching elements of the rotary spool valve, which will be further described herein. These one or more grooves **266** generally exist only around a part of the manifold chamber **256** so that the latching elements can be inserted into and removed from the grooves **266**.

A valve is provided to control the fluid passageway between the tank **22** and the manifold chamber **256** in the valve manifold body **256**. In the embodiment depicted in the figures, the valve is a rotary spool valve **300**, as shown in FIGS. **6-8**, for example. FIGS. **15** and **16** show the rotary spool valve **300** positioned next to the manifold body **250**, ready to be inserted into the manifold chamber **256**. The rotary spool valve **300** is generally cylindrical and positioned at least partially within the generally cylindrical cavity that constitutes the manifold chamber **256** (FIG. **15**) and at least partially within the generally cylindrical cavity **160** (FIG. **10**) of the open top container **156**.

Other types and configurations of rotary valves are usable. For example, certain elements could be switched in their orientation. In one embodiment, grooves **266** could be swapped from valve manifold body **256** to open top container **156**, in which case rotary spool valve **300** would have latching elements at an opposite end to engage with grooves **266** and would further have a handle at an opposite end to control the engagement of the latching elements.

Now referring to FIGS. **6-8**, the rotary spool valve **300** has an axial fluid passage **302** that intersects with an end surface **304** of the rotary spool valve **300**. The rotary spool valve **300** also has a radial fluid passage **306** that intersects with a radial surface **308** of the rotary spool valve **300**. Now referring to FIGS. **15** and **16**, the radial fluid passage **306** is configured to be in fluid communication with the manifold chamber **256** through the axial fluid passage **302**. In addition, the rotary spool valve **300** has one or more latching elements such as latching tabs **310** that are configured to engage the one or more latching grooves **266** of the valve manifold body **250**. The rotary spool valve **300** further includes one or more seals **312** about the intersection of the radial fluid passage **306** with the radial surface **308** of the rotary spool valve **300**, as well as one or more outer seals **316** along radial surface **308**. In some embodiments, there is also a handle **314** secured to an end of the rotary spool valve **300**, as shown in FIGS. **7** and **8**.

Various embodiments of seals **312**, **316** are usable. In the embodiment depicted in FIGS. **7** and **8**, seals **312**, **316** are formed by a sealing sleeve **318** that is configured to be installed onto or over a valve body. For example, sleeve **318** may be a generally tubular part that has various openings for providing clearance with features of the rotary spool valve **300**, such as radial passage **306** and latching tabs **310**. In some embodiments, sleeve **318** is not separately installed onto spool valve **300**, but rather is overmolded onto spool valve **300**. Sleeve **318** further includes raised features as necessary to constitute seals **312**, **316**. These features that form seals **312**, **316** are generally configured to provide a fluid-tight seal against cylindrical cavity **160** when rotary spool valve **300** is assembled to cylindrical cavity **160** of open top container **156**. The valve body **317** is illustrated without the sealing sleeve **318** in FIG. **9**. Radial fluid passage **306** is defined in the radial surface **309** of the valve body **317**.

In an alternative embodiment, the valve body **317** of FIG. **9** does not have a sealing sleeve fitted over it. Instead, grooves may be provided on the valve body **317** for receiving o-ring or other seals that constitute seals **312**, **316**.

When the rotary spool valve **300** is assembled into cylindrical cavity **160** of open top container **156** and manifold chamber **256** of manifold body **250** it is rotatable between at least two rotational positions. FIGS. **15** and **16** are exploded views of the valve tank interlock assembly, including the manifold body **250** and the rotary spool valve **300**. In a first rotational position, latching tabs **310** are free of latching grooves **266**, such that rotary spool valve **300** is free to be moved axially into and out of the bore of manifold chamber **256**. FIG. **18** is a cross-sectional view of the rotary spool valve **300** within the manifold chamber **256** where the rotary spool valve **300** is in the first rotational position. Furthermore, in the first rotational position, radial fluid passage **306** does not register or align with water passage **158** within cylindrical cavity **160**. In the first rotational position, seals **316** prevent water in tank **22** from leaking out of cylindrical cavity **160**. In some embodiments such as seen in FIG. **8**, a seal **320** is provided on radial surface **308** of rotary spool valve **300** that aligns with water passage **158** when rotary spool valve **300** is in the first rotational position and that directly seals water passage **158** from manifold chamber **256**. However, in some other embodiments, seal **320** is not present. In this case, water may be able to travel from tank **22** to water passage **158** and then to the gap between radial surface **308** of rotary spool valve **300** and cylindrical cavity **160**. However, this water will not be able to travel to manifold chamber **256** or escape from cylindrical cavity **160** because of seals **316** that form a seal of radial surface **308** against cylindrical cavity **160**.

In the second rotational position of rotary spool valve **300**, as shown in the cross-sectional view of FIG. **10**, the radial fluid passage **306** in rotary spool valve **300** is aligned with water passage **158** in open top container **156**. The alignment of these passages establishes a water communication pathway from tank **22** through radial fluid passage **306**, to axial fluid passage **302** and into manifold chamber **256**, where passages to water supply connection **252** and water drain connection **254** are defined, as described above. When rotary spool valve **300** is in the second rotational position, seal **312** is positioned about the opening for water passage **158**, such that water is generally sealed from the radial surface **308** of rotary spool valve **300**. However, any water that does pass by seal **312** is prevented from entering manifold chamber **256** or from flowing out of cylindrical cavity **160** by virtue of seals **316**. The second rotational position of rotary spool valve **300** therefore allows the flow of water into and out of tank **22** to be controlled by the water control valves in the first and second water supply passages **258**, **260**. The second rotational position of rotary spool valve **300** also includes the one or more latching tabs **310** being engaged with the grooves **266** of the valve manifold body **250**. The engagement of latching tabs **310** to grooves **266** causes rotary spool **300** to be locked in place such that axial movement of the rotary spool valve **300** is prevented. Because rotary spool valve **300** is also engaged with cylindrical cavity **160** of open top container **156**, the prevention of axial movement of rotary spool valve **300** also prevents movement of open top container **156**, effectively locking open top container **156** in its operational position.

When a humidifier constructed according to the principles of the present invention is in operation, the rotary spool valve **300** is in the second, locked, rotational position. As described above, this position allows the humidifier to function by allowing supply water to flow into tank **22** through rotary spool valve and allowing drain water to flow out of tank **22** through rotary spool valve **300**. When the user intends to clean the tank, it may be necessary for the user to provide some input to the controls of the humidifier so that both water control valves in the first and second water supply passages **258**, **260** will be kept closed during the cleaning process. Furthermore, normally the humidifier will be configured as part of the tank cleaning process to open the valve in the drain passage **254** to allow substantially all of the water in tank **22** to be removed through the drain. The user then uses handle **314** to rotate rotary spool valve to the first, unlocked, position. In this position, the water passage **158** is sealed and the latching tabs **310** are disengaged from corresponding grooves **266**. The open top container **156** can then be removed from main structure **150**. It is possible if the drain passages are obstructed or not functioning properly that there may still be water in the open top container **156** when the user attempts to remove it. Moreover, because the humidifier operates by heating water in the tank to convert it to steam, the remaining water may be very hot. The rotary spool valve **300** advantageously seals the water passage **158** in open top container **156** so that this water does not empty out when the open top container **156** is removed from main structure **150**. If there is water in open top container **156** when the user removes it from main structure **150**, the user can carry the open top container **156** to a sink or drain and then pour it out. The user can then manually clean the open top container **156**.

To reassemble open top container **156** to main structure **150**, the user brings open top container **156** into alignment with main structure **150** and manifold body **250** and inserts the portion of rotary spool valve **300** that extends outwards from cylindrical cavity **160** into manifold chamber **256** of valve manifold body **250**. The rotary spool valve **300** is positioned so that the one or more locking tabs **310** are turned to be brought into alignment with grooves **266** of the valve manifold body **250**, and then rotary spool valve **300** is rotated so that locking tabs **310** enter and engage with grooves **266**. In this way, rotary spool valve **300** is locked to valve manifold body **250** which in turn causes open top container **156** to be secured to main structure **150**. The humidifier can then resume normal operation. In some embodiments, the user can provide an indication, such as pressing a button or switch, to indicate that the humidifier has been reassembled after cleaning and can resume operation.

The present invention should not be considered limited to the particular examples described above, but rather should be understood to cover all aspects of the invention as fairly set out in the attached claims. Various modifications, equivalent processes, as well as numerous structures to which the present invention may be applicable will be readily apparent to those of skill in the art to which the present invention is directed upon review of the present specification. The claims are intended to cover such modifications and devices.

The above specification provides a complete description of the structure and use of the invention. Since many of the embodiments of the invention can be made without parting from the spirit and scope of the invention, the invention resides in the claims.

What is claimed is:

1. A steam humidifier comprising:
- (i) a tank for containing water to be heated to generate steam;
- (ii) a water connection manifold having a manifold chamber in fluid communication with a water supply passage and a water drain passage; and
- (iii) a rotary valve configured to control a fluid passage between the tank and the manifold chamber and further configured to control the position of one or more locking features, the rotary valve being rotatable between:
  - (a) a first locked position in which the fluid passage between the tank and the manifold chamber is open and the one or more locking features are engaged to lock the tank to a structure of the steam humidifier; and
  - (b) a second unlocked position in which the fluid passage between the tank and the manifold chamber is closed and the one or more locking features are disengaged to unlock the tank from the structure of the steam humidifier.

2. The steam humidifier of claim **1**, where a handle is attached to the rotary valve.

3. The steam humidifier of claim **1**, where the rotary valve is a rotary spool valve.

4. The steam humidifier of claim **3**, where the tank further comprises a heater element for heating water to generate steam.

5. The steam humidifier of claim **3**, where the water supply passage and the water drain passage are each configured to receive water control valves.

6. The steam humidifier of claim **3**, where the rotary spool valve further comprises one or more seals configured to seal the tank from the manifold chamber when the rotary spool is in the second unlocked position.

7. The steam humidifier of claim **5**, where the tank is removable from the steam humidifier when the rotary spool valve is in the second unlocked position and the water control valves in the water supply passage and the water drain passage are each in a closed position, and where the rotary spool valve remains with the tank when removed.

8. A steam humidifier comprising:
- (i) a tank for containing water to be heated to generate steam, the tank having:
  - (a) a generally cylindrical cavity; and
  - (b) a water passage fluidly connecting a bottom portion of the tank to the generally cylindrical cavity;
- (ii) a main structure configured to support the tank;
- (iii) a valve manifold body configured to be supported by the main structure, the valve manifold body defining:
  - (a) a water supply connection;
  - (b) a water drain connection;
  - (c) a manifold chamber including a second generally cylindrical cavity;
  - (d) a first water supply passage fluidly connecting the water supply connection to the manifold chamber, the first water supply passage further configured to receive a water supply control valve;
  - (e) a second water supply passage fluidly connecting the water drain connection to the manifold chamber, the second water supply passage further configured to receive a water drain control valve; and
  - (f) one or more latching features;
- (iv) a rotary spool valve, the rotary spool valve being generally cylindrical and positioned at least partially within the generally cylindrical cavity of the manifold chamber and at least partially within the generally cylindrical cavity of the tank, the rotary spool valve defining:
  - (a) an axial fluid passage that intersects with an end surface of the rotary spool valve;
  - (b) a radial fluid passage that intersects with a radial surface of the rotary spool valve and is configured to be in fluid communication with the manifold chamber through the axial fluid passage;
  - (c) one or more latching tabs configured to engage the one or more latching features of the valve manifold body; and
  - (d) one or more seals about the intersection of the radial fluid passage with the radial surface of the rotary spool valve;
- (v) a handle secured to an end of the rotary spool valve.

9. The steam humidifier of claim **8**, where the handle is configured to rotate between at least two positions.

10. The steam humidifier of claim **9**, where in a first position of the handle, the radial fluid passage of the rotary spool valve registers with the water passage of the tank.

11. The steam humidifier of claim **10**, where in a first position of the handle, the one or more latching tabs of the rotary spool valve are engaged with the one or more latching features of the valve manifold body.

12. The steam humidifier of claim **9**, where in a second position of the handle, the radial spool valve blocks the water passage of the tank.

13. The steam humidifier of claim **12**, where in a second position of the handle, the one or more latching tabs of the rotary spool valve are disengaged from the one or more latching features of the valve manifold body.

14. The steam humidifier of claim **8**, where the one or more latching tabs project from the radial surface of the rotary spool valve.

15. The steam humidifier of claim **8**, where the seal structures comprise a sleeve fitted over the rotary spool valve.

16. The steam humidifier of claim **10**, where the generally cylindrical cavity of the tank is coaxial with the generally cylindrical cavity of the manifold chamber.

17. A method of removing a tank of a steam humidifier, the method comprising:

(i) closing one or more valves in a valve manifold body to isolate a water supply and a water drain from a manifold chamber of the valve manifold body;

(ii) rotating a handle attached to a rotary spool valve to cause a fluid passage leading from the tank to the manifold chamber of the valve manifold body to be blocked and causing locking features of the rotary spool to disengage from a supporting structure of the steam humidifier;

(iii) removing the tank and the rotary spool valve from the supporting structure.

18. The method of claim **17**, where the rotary spool valve includes a radial fluid passage that intersects with a radial surface of the rotary spool valve and an axial fluid passage that intersects with an end of the rotary spool valve, where the radial fluid passage and the axial fluid passage intersect with each other, such that prior to rotating the handle, the axial and radial fluid passages form a fluid passage from the tank to the manifold chamber.

19. The method of claim **18**, where the rotary spool valve further comprises one or more seals about the radial fluid passage that effect a seal of the fluid passage of the tank after the handle has been rotated.

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